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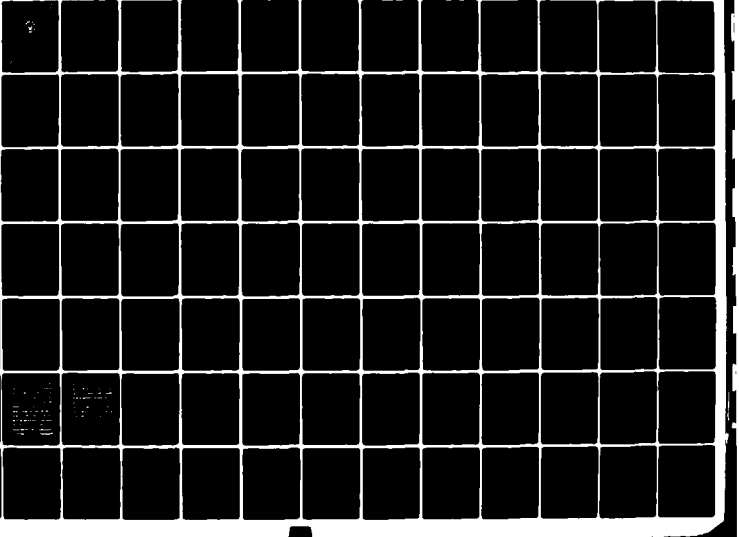

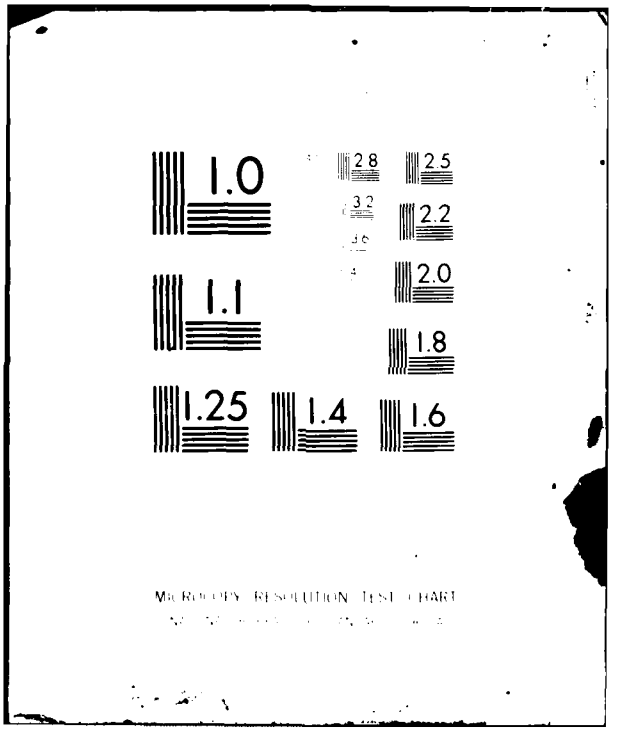
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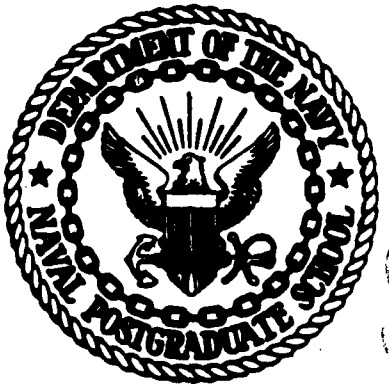

THESIS

A CROSS COMPILER AND PROGRAMMING SUPPORT SYSTEM FOR THE HP41CV CALCULATOR

by

James Norman Richmann

September 1981

Thesis Advisors: S. H. Parry
R. H. Shudde

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With growing Army-wide use of programmable calculators, a system is needed to support the programming and testing of calculator software. This thesis provides a FORTRAN IV program to enable an operations research analyst to more efficiently write and document HP41CV calculator programs. Optical bar code readable by the HP41CV is generated by the program. Also given is an

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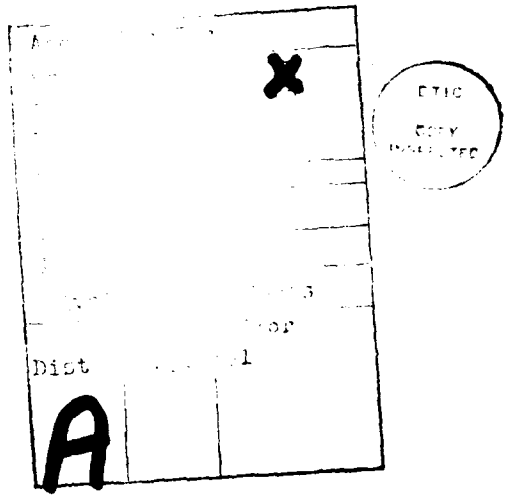

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A Cross Compiler and Programming Support System for the HP41CV Calculator

by

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Captain, United States Army
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Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

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September, 1981

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ABSTRACT

With growing Army-wide use of programmable calculators, a system is needed to support the programming and testing of calculator software. This thesis provides a Fortran IV program to enable an operations research analyst to more efficiently write and document HP41CV calculator programs. Optical bar code readable by the HP41CV is generated by the program. Also given is an IBM EXEC II program which provides an interactive programming environment including on-line, self contained instructions. To illustrate the use of the system and the quality of the finished bar code and calculator program listings, examples are given including single variable statistics and linear programming. A final example provides a set of short utility routines which illustrate how programs can be developed for use in a calculator read-only-memory.

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I. INTRODUCTION

For the Army to fight effectively in a resource scarce environment, the quantitative decision making techniques of operations research are important skills for Army staff officers. Staff officers are expected to be able to put numbers in their estimates when briefing commanders. They are expected to be able to measure and evaluate complex operations and subordinate units. They are expected to be frugal managers of time and money. And above all, staff officers must be able to apply sound, quantified reasoning in planning how to win the air-land battle.

The use of hand-held programmable calculators by Army staff officers has the potential for improving the use of quantitative decision making techniques throughout the Army. Faster and more accurate than paper and pencil, the calculator is less expensive and more portable than larger computers. Even when compared to the latest micro-computer systems or to portable terminals used for distributed data processing, the hand-held programmable calculator offers advantages in cost, reliability, power consumption and emission of electromagnetic radiation. Hand-held programmable

calculators have already been successfully used by soldiers in the field for applications in artillery fire direction, surveying, and navigation. In addition, large numbers of Army officers own their own pocket calculators and routinely use them for staff planning and reporting functions.

In January of 1981 the U. S. Army Command and General Staff College at Fort Leavenworth, Kansas selected a programmable calculator for the Combined Arms and Services Staff School (CAS ^{3} .) Using both resident and non-resident instruction, this course is designed to teach all Army captains staff techniques and procedures. As a significant part of the curriculum, the students are introduced to subjects such as statistics and regression, decision theory, combat modeling and linear programming. Considering the large number of officers projected to attend this course in future years, this course represents the most widespread training in operations research techniques ever attempted by the Army. The decision to provide a sophisticated calculator to these students on an experimental basis was made for two fundamental reasons. First, the availability of a calculator with immediate field utility should motivate the student to apply the quantitative techniques as compared to the student who would be forced to do all calculations by

hand. Second, the power of the calculator permits classroom discussion of techniques such as linear programming and regression which are very difficult and time consuming to perform manually.

This thesis documents the author's work to support the use of a calculator in the Combined Arms and Services Staff School. Initially, the intent was to produce a series of lesson materials incorporating the use of the calculator on a series of operations research topics which have immediate application for the Army division level staff officer. Instead, the work accomplished focused on the design and construction of a system to make the programming and testing of calculator programs easier and more efficient. Except for the introduction, this thesis is written for the person wishing to implement the programming support system described. The implementor must have a detailed knowledge of the instruction set and programming characteristics of the HP41CV calculator as described in Wickes [Ref. 1: pp. 6-20]. For the eventual user of the system, as compared to the implementor, the system itself provides on-line documentation on how to use the system and what commands and options are available. Figure 1 shows the command menu displayed on the terminal screen by this interactive program:

Figure 2 gives a more detailed explanation of each of the commands; and Figure 3 displays the on line introductory material that is provided to new users of the system. For the user, a knowledge of the information contained in the calculator owner's handbook [Ref. 2] is sufficient to begin writing calculator programs using the support system described.

The calculator selected by the Command and General Staff College, the Hewlett-Packard HP41CV, typifies the state of the art in off-the-shelf calculator technology. While not without disadvantages, this calculator was selected because of its power and features which make it easier for Army staff officers to use. First and most important of these features is the ability of the calculator to manipulate alphabetic characters in addition to numeric data. The calculator can display the name of a variable when input data is required or label output when the calculation is completed. With this feature, the calculator helps the user know what data to input or what action to take next. It also helps alleviate the need for constant reference to printed instructions which are difficult to use under field conditions.

```
HP41C CROSS COMPILER ..... program name .....EDITION=17 SEP 81
SELECT DESIRED COMMAND FROM THE FOLLOWING:

PF-KEY    COMMAND  CODE  ACTION TAKEN BY PROGRAMMING  COMMAND SYSTEM

PF13       STOP      S   GETS YOU OUT OF THE HP41C CROSS COMPILER
PF14       HELP      H   SHORT EXPLANATION OF HOW TO USE THE CROSS COMPILER
PF15       ENTER     E   INTERACTIVE PROGRAM ENTRY (NO FILE CREATED)
PF16       BAR       B   SUBMIT JOB FOR PHYSICAL PRODUCTION OF BAR CODE
PF17       NEW       N   BEGIN WORK ON A NEW PROGRAM OR NAMED SUBROUTINE
PF18       DIREC     D   DIRECTORY OF COMMANDS
PF19       LIST      L   DISPLAY  NAMES   OF HP41C PROGRAMS ON DISK
PF20       OCOMP   C O   OFFLINE COMPILE AND AUTO GENERATION OF BAR CODE
PF21       PRINT     P   PRODUCE A HARDCOPY PRINTED LISTING OF THE PROGRAM
PF22         *       *   RESERVED FOR FUTURE USE BY HP41 EMMULATOR
PF23       COMP      C   COMPILE A SOURCE LISTING ON CMS DISK
PF24       XEDIT     X   EDIT THE PROGRAM USING THE CMS FULL-SCREEN EDITOR
           ERASE         ERASE THE SOURCE FILE,LISTING FILE AND TEXT FILE
           CMS           ALLOWS EXECUTION OF ANY VALID CMS COMMAND
           CP            ALLOWS EXECUTION OF ANY VALID CP COMMAND
INPUT COMMAND:
```

Figure 1: Programming Environment Command Menu

PF-KEY	CMD	CODE	ACTION TAKEN BY PROGRAMMING COMMAND SYSTEM
PF13	STOP	S	THIS COMMAND IS USED WHEN YOU WISH TO STOP PROCESSING HP41C PROGRAMS AND RETURN TO CMS. IF YOU ARE EXECUTING A FUNCTION THAT WAS INVOKED FROM THE COMMAND MENU, IN MOST CASES PF13 WILL RETURN YOU TO THE MENU, AND BY PRESSING PF13 AGAIN YOU WILL RETURN TO CMS.
PF14	HELP	H	THIS COMMAND IS USED TO DISPLAY THE DETAILED EXPLANATION OF THE MENU COMMAND PROCESSOR AND ITS AVAILABLE COMMANDS. IF YOU HAVE QUESTIONS ABOUT THE PROCESS OF WRITING ACTUAL HP41C PROGRAMS YOU SHOULD CONSULT THE HP41 OWNER'S HANDBOOK.
PF15	ENTER	E	THIS COMMAND IS USED TO ENTER A PROGRAM USING THE CROSS-COMPILER IN AN INTERACTIVE MODE. THE ADVANTAGE OF THIS MODE IS THAT ANY SYNTACTICAL ERRORS IN THE HP41C PROGRAM ARE IMMEDIATELY IDENTIFIED BY THE CROSS-COMPILER AND AN ERROR MESSAGE IS SHOWN ON THE SCREEN. THE DISADVANTAGE IS THAT THE USER IS TOTALLY RESPONSIBLE FOR UPPER AND LOWER CASE BEING ENTERED PROPERLY.
PF16	BAR	B	THIS COMMAND IS USED ONCE THE HP41C PROGRAM IS WRITTEN AND COMPILED WITHOUT ERRORS. IT SUBMITS A JOB TO MVS BATCH FOR THE PHYSICAL PRODUCTION OF THE BAR CODE.
PF17	NEW	N	THIS COMMAND IS USED TO DIRECT THE ATTENTION OF THE COMMAND PROCESSOR TO A NEW HP41 PROGRAM SOURCE FILE. WHEN USED TO INITIATE NEW HP41C PROGRAMS, IT AUTOMATICALLY INSURES THAT A NEW FILE IS CREATED WITH FILETYPE "HP41" AND PROMPTS THE USER FOR THE PROGRAM TITLE WHICH IS THE MANDATORY FIRST LINE OF EVERY HP41C SOURCE CODE FILE.
PF18	DIREC	D	THIS COMMAND DISPLAYS THE FULL COMMAND MENU. IT HAS PRIMARY USE WHEN YOU FINISH AN OPERATION THAT FILLS THE SCREEN WITH TEXTUAL MATTER AND YOU RECEIVE ONLY THE PROMPT "INPUT COMMAND".

Figure 2: List of Commands

PF-KEY	CMD	CODE	ACTION TAKEN BY PROGRAMMING COMMAND SYSTEM
PF19	LIST	L	THIS COMMAND DISPLAYS "FLIST" FOR THOSE HP41C PROGRAMS THAT ARE ACTIVE ON YOUR A DISK. FROM THIS LIST, YOU CAN ERASE OLD PROGRAMS TO RELEASE DISK STORAGE, CHANGE THE NAME OF PROGRAMS, OR EXAMINE THE CONTENTS OF ANY PROGRAM.
PF20	OCOMP	C O	THIS COMMAND IS USED TO PRODUCE AN "OFFLINE" COMPILE. THE PROGRAM LISTING IS AUTOMATICALLY PRINTED IN HARD COPY ON THE HIGH SPEED PRINTER. IF THE COMPILE WAS WITHOUT ERROR THE BAR CODE IS AUTOMATICALLY PRODUCED.
PF21	PRINT	P	THIS COMMAND PRINTS A COPY OF THE "LISTING" FILE ON THE HIGH SPEED PRINTER. IF YOU WISH TO HAVE A PRINTED COPY OF THE SOURCE CODE WITHOUT THE CROSS-COMPILER'S FEEDBACK, IT IS BEST TO SIMPLY PRINT THE SOURCE CODE CMS FILE BY ISSUING THE CMS PRINT COMMAND.
PF22	GO	G	THIS COMMAND IS USED TO INVOKE THE HP41C EMMULATOR PROGRAM WHICH ALLOWS YOU TO TEST EXECUTION OF THE PROGRAM ON THE LARGE COMPUTER. THE EMULATION PROGRAM WILL EXECUTE THE PROGRAM EXACTLY AS YOUR CALCULATOR WOULD. THIS COMMAND HAS NOT BEEN IMPLEMENTED AS OF 17 SEP 81.
PF23	COMP	C	THIS COMMAND IS USED TO INVOKE THE CROSS COMPILER TO TRANSLATE AN HP41C PROGRAM WRITTEN ON CMS DISK IN SOURCE CODE FORM. AFTER THE COMPILE THE USER IS AUTOMATICALLY PLACED IN THE CMS BROWSE MODE FOR THE OUTPUT "LISTING" FILE THAT RESULTED FROM THE COMPILE.
PF24	XEDIT	X	THIS COMMAND IS USED TO INVOKE THE FULL-SCREEN EDITOR TO MAKE MODIFICATIONS TO THE HP41C SOURCE CODE FILE.

Figure 2 (Continued)

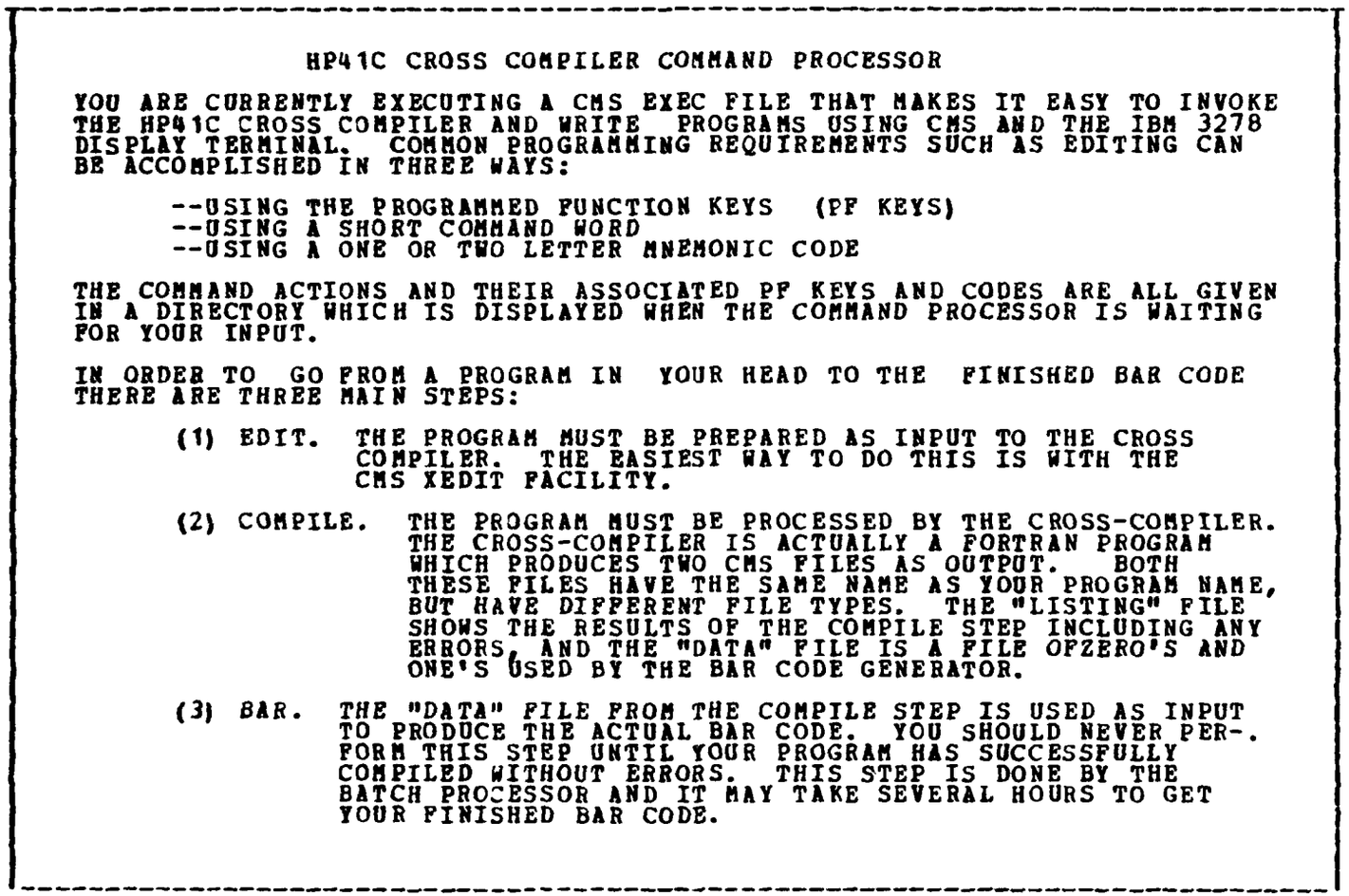


Figure 3: On-Line Introductory Material

A second important feature is the multiplicity of means by which programs can be entered into the calculator. Magnetic cards, read only memory, and optical bar code are all available and each has advantages depending on the situation. For the long term, read only memory offers the ability to retain very large programs (in excess of 8000 bytes) and the simplest and most reliable means of entering programs into the calculator under field conditions. For the short term, optical bar code offers the least expensive method of reproducing and distributing calculator software that has not been subject to extensive field testing. In addition, as shown in this thesis, the optical bar code can provide an important link between a main-frame computer and the hand-held calculator.

A third important feature of the HP41CV is its relatively large memory capacity as compared to programmable calculators such as the Texas Instruments TI-59. A large amount of memory permits the solution of larger, often more realistic problems than could previously be solved on a hand-held device. A demonstration program given in this thesis for linear programming is an example of an application where the full memory capability of the HP41CV is required to be able to solve realistic problems.

To take advantage of the calculator's unequalled ec and portability, the operations research analyst is challenged to overcome its limits of speed and memory capacity. The preparation of calculator software is as difficult, if not more so, than the preparation of software for larger computers. To accomplish the most possible with the handheld device, the calculator programmer is often forced to write programs which are very difficult to comprehend when examined by other programmers. As Dahl, Dijkstra and Hoare [Ref. 3: pp. 1-10] point out there are limits to human competence which interfere with the programming process. In the past, with less mature calculators which constrained the typical program to a few hundred program steps, these limits to human competence were neither as apparent nor as economically important as they are with the HP41CV. Accordingly, it is not envisioned that the average Army officer who uses the HP41CV on real world problems which push the calculator to the limits of its capability would write their own programs. In particular, it was never intended that the students in the Combined Arms and Services Staff School would be taught calculator programming. It is a tribute to the power of the device and the quality of the calculator software when a relatively inexperienced user can run complex

programs using little more than the digit entry keys and the run-stop key on the calculator. This does not mean that the user must not have a clear understanding of his problem or the solution technique, but rather it means that the calculator should not require programming skill or extensive training prior to application.

The growing complexity of calculator programs described above and the realization that calculator programs for Army field use are not programmed in the field, suggest the need for a system to support the development, distribution and maintenance of calculator software. An operations research analyst or other professional programmer must be able to more efficiently prepare calculator programs than by keying them into the hand-held device. By preparing the programs initially on a larger computer, such as the IBM 3033, the programmer can use the speed and storage capability of the larger machine to great advantage. In addition, the availability of a full-screen video text editor speeds the process of program revision and maintenance. By providing a capability to integrate comments directly into the source code on the larger computer, program documentation is more easily provided. Essentially the idea is that a programmer would write the calculator program using a terminal

connected to a large computer. After the calculator program is entered into the large computer, a compiler program running on the large computer would check the calculator program for errors and convert the mnemonic instructions into the "key codes" which are the numeric instructions actually executed by the calculator. Then an emulator program running on the large computer would take the numeric instructions from the compiler and execute the program--in effect making the large computer produce the same effects as the calculator only much faster and more efficiently for the programmer. Finally, when the program has been written and tested on the large computer, optical bar code is produced which allows for the economical distribution and use of the program in the field. To encourage the calculator programmer to use the system described, this process should occur in an interactive programming environment in which the user can move from one step to another by issuing simple commands such as those listed and described in Figure 2 and receive help or on line instruction whenever desired. Under this proposed system, the advantages of both the larger computer and the hand-held calculator are used appropriately in a mutually supporting manner. This thesis presents two of the components of this proposed system. First, an IBM EXEC II

program is given which provides an interactive programming environment for users operating under IBM's Conversational Monitor System (CMS.) A short discussion of the design of this program and a complete copy of the source code is contained in Appendix D to this thesis. Secondly, a cross compiler written in IBM standard FORTRAN IV is provided for translating calculator mnemonic instructions into the key codes necessary for use by the emulator and also for the production of optical bar code. The term cross compiler refers to the fact that the program runs on one machine (the larger computer) but compiles programs for another machine (the calculator.) A discussion of the design of this program and a complete copy of the source code is contained in Appendix D. To make the program easier to understand and adapt to new requirements, it is modularized into 24 subroutines and is heavily commented.

To illustrate the use of the system, two of the six example programs originally planned are provided in this thesis. Revised plans now call for the remaining four example programs to be issued at a later date as Naval Postgraduate School technical reports. Because the reasons for the delay constitute some of the most important lessons learned from this thesis research, Chapter 2 documents the process

with a technical discussion of the factors involved. The major conclusions described in Chapter 2 are the need for a prioritized list of criteria with which to evaluate calculator programs and the need for more structure in the programming process. Chapter 2 is technically oriented and assumes the reader is familiar with the concepts of structured programming.

Each of the calculator program examples is described in a separate appendix in which the documentation listed in

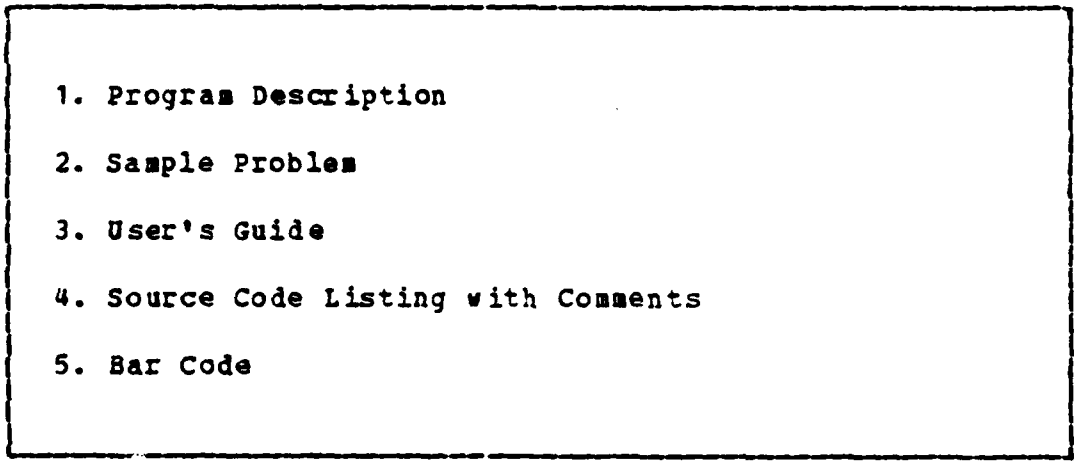


Figure 4: Components of Program Documentation

Figure 4 is provided. The first example on single variable statistics is documented in Appendix A and uses the calculator in an area where calculators have long been used, but does so in a way that shows the unique capabilities of the

H41CV. A second example on linear programming is documented in Appendix B and illustrates an area where calculators have not received widespread application. Most calculator linear programs which have been published to date have been either incomplete algorithms or have been limited to very simple problems.

A third example, which by its nature does not conform to the documentation standards outlined above, describes a set of utility routines which could be distributed in read only memory. Programs for read only memory have different characteristics from other calculator programs and Appendix C is provided to illustrate some of these differences.

II. THE PROGRAMMING ENVIRONMENT

A. CHAPTER OVERVIEW

This Chapter examines calculator programming within the context of the author's experience in preparing HP41CV programs in support of the Combined Arms and Services Staff School. With the advanced capabilities and features of the HP41CV, it was hoped that a complete package of software could be prepared quickly. To document why this did not occur, this chapter will examine strengths and weaknesses of the calculator in relationship to a collection of techniques referred to in computer science as structured programming. For the reader unfamiliar with this term, the previously cited work by Dahl, Dijkstra, and Hoare [Ref. 3] is recommended. This chapter is technically oriented and does assume familiaritiy with structured programming concepts.

When programming calculator programs for personal use, most programmers, including the author, do not find the task difficult. Programming a hand-held calculator with the capabilities and features of the HP41CV can be a rewarding experience. It is rewarding to master the algorithm of an operations research technique on a hand-held device. The

educational value in programming the calculator has been recognized by many educators, including Hamming [Ref. 4: pp. 2-3] and Weir [Ref. 5: pp. xii-xiii]. Providing a program for general distribution which makes optimum use of the calculator is quite a different situation. It was the author's experience that programs, which gave correct answers when used by the author, often had to be completely re-written several times before being acceptable. This problem became more acute as the size of the programs grew beyond 400 program steps, for at that size it became increasingly difficult to modify programs without affecting the total design. The major conclusions described in this chapter are the need for a prioritized list of criteria with which to evaluate calculator programs and the need for more structure in the programming process.

B. STRUCTURED PROGRAMMING WITH THE HP41CV

1. The Need for Structure

To increase the efficiency of the programming process, a collection of techniques known as structured programming has received widespread attention in the computer science community. While there is no one definition of structured programming, it does require three essential characteristics. First, there must be a logical structure

to the program which reflects the nature of the problem to be solved and any constraints imposed upon the solution. Second, the systematic process of stepwise refinement is used to limit the complexity of program segments. Third, the programming language must reflect the logical structure of the program and assist in stepwise refinement. These three characteristics represent not so much a detailed recipe for program development as they do a philosophy of how programs can be more efficiently written. It was with this philosophy in mind, that a calculator programming support system was proposed which could take into account the strengths and weaknesses of the calculator; balance the structured programming philosophy with the other criteria listed below; and thereby solve the problems encountered in writing calculator software for the Combined Arms and Services Staff School.

2. Fundamental Limitations of Calculators

Writing programs to solve complex problems on a hand-held calculator is difficult both because of inherent limitations in the calculation speed and memory capacity of the machine and also the inability of the calculator's native programming language to directly support structured programming constructs. In many respects, the task is

similar to writing assembly level language programs for larger computers. Calculator programming features a powerful instruction set including advanced mathematical functions but lacks any ability to refer to variables by name instead of storage address. Like assembly language, the calculator's programming language consists of short mnemonic instructions typically followed by the storage location of the data to which the operation is to be applied. While a large amount of computer programming is still done in assembly language, it is generally accepted that programming in a higher level language such as FORTRAN is preferable. Programs written in an assembly language take more time to write and are not as easily changed as higher level language programs. Also, because they depend on the instruction set of a particular machine, they can not be easily transfered from one computer to another. These same disadvantages apply to calculator programming. In addition, because the hand-held device does not have the speed and memory capability of the larger machine, the calculator programmer must be even more mindful of the need to optimize his program to save program steps and execution time.

3. Modular Design

The HP41CV supports structured programming as well or better than any other hand-held calculator. As described in the owner's manual [Ref. 2: pp. 177-196], the machine primitive instruction XEQ encourages the construction of modular programs using calculator subroutines. Each subroutine can be a self-contained unit capable of being written and tested independently and used by multiple programs. This modularity is most strongly encouraged when routines in read only memory are used, for then the application programmer can significantly reduce the number of program steps in his own program. This modularity, however, is not complete, since all variables are globally referenced and can be changed deliberately or inadvertently by any subroutine. This problem is no more apparent than with the use of read only memory, since one of the most limiting factors in using the read only memory programs as subroutines is conflict in the use of common registers. Also, unlike the modularity required in truly structured programs, there is no restriction limiting a subroutine to a single entry and a single exit point. In structured programs, such limits on entry and exit serve to define the fundamental building blocks by which stepwise refinement is made possible. With

the calculator, however, multiple entry and exit points are most useful for allowing a common routine to handle a duplicity of problem conditions. In this thesis, for example, programs are given for which two standard entry points are provided. One entry point uses an alpha-numeric label and an audio prompt to speed data entry, while a second entry point uses the alpha-numeric label but suppresses the audio tone. After data entry, the value entered is displayed, and the user is required to verify the accuracy of the data entered. By using the same subroutine with different entry points, memory space is saved overall at the sacrifice of the structured programming philosophy.

4. Control of Program Flow

A basic deficiency prohibiting the HP41CV from directly supporting structured programming is the way in which program flow is controlled. Programming languages which support structured programming typically have instruction constructs such as WHILE--ENDWHILE, REPEAT--UNTIL, or LOOP--QUIT--ENDLOOP which make programming loops clear and concise. Constructs such as IF--THEN--ELSEIF--ELSE--ENDIF and the CASE statement make the evaluation of conditional expressions efficient and relatively error free. Also, structured programming languages typically discourage the

use of GOTO unconditional transfers because they lead to confusing code. In contrast, the HP41CV programmer must write his own looping constructs and his own conditional evaluation constructs using machine primitive instructions which somewhat obscure the program's basic objective and flow of control. In addition, it is difficult to avoid disturbing pending operations in the stack registers when a conditional statement must be evaluated. As can be seen by the short program shown in Figure 1, the notation of the programming language does not permit structured program flow.

5. Clarification of Program Structure

Because no calculator, including the HP41CV, supports named variables, the use of comments as an integral part of the calculator program is vital if the logical structure of the program is to be made clear as required by structured programming. Comments should provide the variable names when storing and recalling data; they should provide clarification of program flow; and they should mark subroutine boundaries and entry and exit points to make it easier to identify segments of the program. With the HP41CV's stack oriented architecture, it is also frequently useful to display the names of the contents of each of the

Given the number n in the x-register, this program fragment will sum the data values stored in memory locations 1 through n.

Instruction	Comment
LBL "SUM	To execute press "XEQ SUM".
1E3	
/	
1	
+	Establishes a loop counter.
0	Clears x and pushes loop
LBL 00	counter into y.
RCL IND Y	Recall the next data value.
+	Accumulate the sum.
ISG Y	Increment the loop counter.
GTO 00	If more data remains, branch;
RTN	else, quit and display sum.

Figure 5: Example Program to Add n Numbers

stack registers. In Appendix C on common subroutines with read only memory application, a shell sort [Ref. 6: pp. 84-95] routine is given which employs the technique of using comments to display the names of the variables on the stack register.

6. Data Types and Indirect Addressing

Calculator programs represent more than a sequence of keystrokes; they also represent the manipulation and transformation of data. For maximum efficiency, the manipulation of data should be structured so as to prevent common programming errors. For this reason, most computer languages which directly support structured programming enforce data type correspondence between data and operations. Frequently the formal declaration and initialization of variables is also required. The HP41CV handles two types of data--real numbers and alphanumeric characters. While no formal declaration of variables is required, type checking is done automatically and is transparent to the user. Any attempt to perform an arithmetic operation on alpha-numeric data will result in the message "ALPHA DATA" and the program will halt.

Because there is no formal declaration of variables, the programmer writing programs for the HP41CV must use

extreme caution in managing his data set and insuring that the numbers stored and recalled by the calculator program are in fact the data elements desired. A typical example of an improper data reference occurs when a program is using indirect addressing and attempts to store or recall data from a non-existent data register. This programming error is so common that a special error message "NONEXISTENT" is provided by the calculator when this error is detected. Indirect addressing is an important feature which gives the calculator a considerable amount of power and flexibility, but also represents an additional responsibility for the programmer to explicitly control. On the HP41CV all indirect addressing calculations must be specifically provided by the application program--there are no vector or array data types such as usually found with higher level languages. In an attempt to make indirect addressing more transparent to the programmer, an experimental subroutine was prepared to recall an arbitrary element of a matrix stored as a two dimensional array. This subroutine, which is shown in Figure 2, was used in a simultaneous differential equation combat model and the results evaluated. It accomplished the task, but slowed the execution of the program considerably (resulting in an overhead of 10.5 seconds

of extra execution time for every 100 subroutine calls) and did not significantly improve the size or legibility of the application program. Accordingly, this technique is not recommended and indirect addressing remains a task that must be treated explicitly by the application programmer.

C. ADDITIONAL CRITERIA FOR PROGRAM EVALUATION

Calculator programming in many respects resembles a multi-criteria decision problem. On the surface the criteria for program effectiveness are quite straight forward--the program must yield the correct answer, run quickly, require the fewest possible memory registers and be user friendly. Unfortunately, these objectives often conflict and can not always be simultaneously achieved. In particular, the principles of structured programming are often in conflict with the desire to reduce the size of programs and increase their execution speed. It is also true that the objectives of structured programming concern the process of writing programs, whereas the additional criteria listed concern the final program product itself and are therefore logically considered separately. Attempting to achieve all criteria at once can lead to failure, and some tradeoffs must be considered to evaluate programs and guide program development. The following criteria represent

Entry to this routine assumes the x register contains the column number and the y register contains the row number. The base address must be stored in R04 and the dimension of the matrix must be stored in R05.

```
 1 LBL "RCLM
 2 RCL 04          (BASE ADDRESS REGISTER
 3 +               (ADD BASE TO COLUMN NUMBER
 4 X<>Y            (RECALL THE ROW NUMBER
 5 1
 6 -
 7 RCL 05          (DIMENSION OF THE MATRIX
 8 *
 9 +               (ADDRESS IS NOW IN X REG
10 RCL IND X       (RECALL THE DATA DESIRED
11 RTN
12 END
```

Figure 6: Program to Recall an Element of a Matrix

"lessons learned" in developing application programs as examples for this thesis.

1. User Friendliness

User friendly programs consider the application environment and do not task the user to be all knowing or without error in entering data. While individuals differ greatly with experience, the average user will make frequent errors in entering data with the hand-held calculator's small keyboard. In talking with officers who had used the TI-59 calculator in the field for fire direction, it was discovered that most preferred to use the printer with the calculator because it allowed data to be checked after entry. This was in spite of the fact that the printer and calculator combination is more costly, less portable and less suitable for use in the field than the calculator alone. In short, user friendliness was more important than these other criteria. For this reason, it should be mandatory that any calculator programs intended for Army use in the field must allow the verification of data after entry. Because the use of the printer obviates many of the advantages of the hand-held calculator, the printer should not be required for this verification. One of the considerable advantages of the HP41CV is that the large amount of program

memory makes it possible to store the input values and perform this verification. However, programs written with this criteria in mind may not appear be most efficient to the casual observer.

Another important aspect of user friendliness is limiting the complexity of the calculator and the actions required to get results. The typical Army officer has little appreciation for the multitude of scientific and mathematical functions labeling the keys of the HP41CV. Yet the common programming practice of using the top two rows of calculator keys to indicate the identity of a variable either upon input or output increases confusion over the use of the function keys. This works as follows: When local alphabetic labels are used in a program to represent entry points by which a user indicates the identity of an input variable or requests a particular output variable, then the first two rows of keys on the HP41CV become subroutine execution keys pointing to these local labels when the calculator is in user mode. This feature was very important on the HP67 and TI-59 where the lack of alpha-numeric capability required this method of program execution in order to most easily determine the identity of the input or output value, but it is less important on the HP41CV. It is almost always

true that a program which requires the use of local labels is harder to use, and requires more frequent reference to the user instructions than a program which uses only the run-stop key and properly prompts the user and labels output values.

2. Execution Speed

The second most important criteria for a calculator program is that it must yield results relatively quickly. In preparing example programs for this thesis, this point became very clear when testing two particular programs. One program, a simultaneous differential equation combat model, required in excess of 150 data values in order to yield results. It should be noted that it was only with the introduction of the HP41CV that it became feasible to consider such large problems on a hand-held device. To accomodate the size of the model, the program was written so as to economize on program steps at the expense of increased execution time. It became immediately obvious upon initial testing that this had been the wrong priority--for users of the program were not impressed with either the use of the calculator or the utility of the combat model. If such user acceptance is not present, then the calculator program will remain unused, no matter how elegant the design to conserve

memory. In contrast, the linear programming example given in Appendix B was written so as to emphasize speed even if it meant including code redundancy. This program has been well received in part because it is so much faster than paper and pencil methods.

The easiest and most effective technique that is useful in increasing speed is to decrease the number of program steps that the calculator must process inside program loops. For example, if two different program options require similar but slightly different actions within a program loop, it is tempting to insert a program flag check and branching instructions within a loop so as to use the same loop for both conditions. But this means that the calculator must test the flag and branch inside the loop even though the program is probably shorter overall.[1]

Instead, if the application permits, the memory capacity of the HP41CV can be used to best advantage by testing the flag once and then providing separate program loops for the two conditions. Again, this does not appear elegant to the casual observer, but it may result in a more successful program overall. This principle was discovered while

---

[1] Branching is required when the flag tests either set or clear if more than one instruction is required to account for the differences in the two conditions.

programming the single variable statistics program given in Appendix A. Initially, this program used a common loop for all data input and output operations, including reviewing the input data and making individual corrections. By providing a separate, somewhat redundant loop for data correction, the time required to input data points was reduced.

D. A PROGRAMMING SUPPORT SYSTEM

Considering the structured programming philosophy discussed above in paragraph B and the additional criteria for evaluating programs listed in paragraph C, it becomes immediately obvious that programming with the calculator alone will never meet even a majority of these objectives. It must be recognized that the problem under consideration is not how the average person who owns a calculator should proceed to program it for his own personal use, but rather how the Army can best provide the most cost-effective computational resource for field use. For these reasons, a comprehensive programming support system is required. The programming support system outlined here will consider only the requirement for cost-effective preparation and maintenance of the calculator programs and not the broader issues of distribution and logistic support for the entire

calculator system to include hardware, training materials and printed references.

1. A Cross Compiler and Bar Code Generator

The first requirement for an operational support package is to free the programmer from the limitations of the hand-held calculator itself. Even with the printer and other peripherals, the calculator is no match for the larger machine when large programs must be examined or edited. In addition, the calculator is not currently capable of producing its own optical bar code as required for economic reproduction and distribution of the software. Accordingly, a cross compiler for the HP41CV was listed as the first requirement of the programming support system. Such a cross compiler has been written and is the major outcome of this thesis effort. This cross compiler accepts an HP41CV program written in the language of the calculator and returns the finished bar code as output. Any valid HP41CV program will be processed without need for modification by the cross compiler. In addition to the basic language of the calculator, the user is allowed to inject comments directly into the source code with the use of the left parenthesis as a comment indicator mark. The ability to make comments directly in the source code makes the calculator programs

more legible and more easily modified at a later date or by another programmer. Often, well placed comments can make up for a lack of structure in the program itself as far as legibility and maintainability are concerned. Having the comments directly in the source code facilitates their use and helps insure that they are as up to date as the program. For the average programmer, use of unmodified HP41CV source code augmented with a comment indicator will represent the most common use of the cross compiler. The cross compiler is described in more detail in Appendix D including a complete listing of the source code.

2. A Calculator Emulator

After the calculator source code has been processed by the cross compiler, a need exists to be able to run the program without the wait for the generation of bar code. In addition, for the future development of read only memories for the calculator, an emulator program is required because the calculator itself can store only up to 2000 instructions in active random access memory. The read only memory can store up to four times this amount. Thus, the calculator by itself may not be capable of testing extremely large programs or programs with large amounts of constant data also stored in the read only memory. Although an emulator was

not written for this thesis, the design of the cross compiler reflects the need for such a program. For example, the cross compiler generates an intermediate array of decimal integers which repesent the machine language of the HP41CV prior to conversion to binary. It was intended that these decimal integers could be used without modification or further translation within a FORTRAN computed goto statement. Thus, with the difficult translation, instruction parsing and syntax recognition already performed by the cross compiler routines, the emulator could consist of one large FORTRAN loop wherein a decimal integer was addressed in the instruction array by a program pointer variable. The integer is then immediately sent to a computed goto statement which would branch to the appropriate line of FORTRAN code which would simulate the referenced instruction, including updating the stack and the program pointer as appropriate.

3. A Higher Level Language Compiler

The final component in the calculator programming support system would be a program that would translate a higher level language such as PASCAL into HP41CV language which could then be sent to the cross compiler for verification and generation of the bar code and intermediate

calculator language listings. It is the higher level language compiler that would most directly make up for the weakness of the calculator in supporting structured programming. It would be able to increase the modularity of programs, provide for named variables, make indirect addressing transparent and provide structured statements such as WHILE--ENDWHILE and IF--THEN--ELSE. Again, the design of the cross compiler anticipates this requirement and provides a considerable number of subroutines that would also be required by a higher level language compiler. These subroutines include a complete set of string functions for manipulating character data in FORTRAN and an instruction parser. Because it was envisioned that the higher level language compiler would also be able to process statements entered directly as HP41CV instructions, the cross compiler is constructed so that the routine which compiles individual lines of HP41CV source code could be called as a subroutine by the higher level language compiler. Thus, all three major components of the proposed calculator programming support system would work together efficiently.

APPENDIX A

SINGLE VARIABLE STATISTICS EXAMPLE

INTRODUCTION:

Calculating single variable statistics is one of the most frequently used applications of programmable calculators. Army division level staff officers use single variable statistics to summarize and describe data for command briefings and periodic reports. The text by Mendenhall, Scheaffer and Wackerly [Ref. 7: pp. 3-13] is recommended as an introduction to the statistical measures calculated by the program given in this appendix. This program automatically calculates:

- Mean and Median
- Sample Standard Deviation
- Sum of the Squared Deviations about the Mean
- Coefficients of Skewness and Kurtosis
- Minimum, Maximum and Range
- Histogram Cell Frequencies

A single variable statistics program has been given as an example because of its immediate utility to the staff officer and to illustrate several features of the HP41CV which make it a superior device for Army field use. The most important of the these features is alphanumeric prompting for input data values. The program given in this appendix provides an alphanumeric prompt for every input and output value and requires only the digit entry keys and run/stop key for data entry. Another important feature of the HP41CV used by this program is its large memory capacity. This program retains up to 219 data points in the calculator's memory to allow the user to review the input data and make corrections during data entry. The large amount of memory allows the calculator to sort the data and calculate the order statistics including the minimum, maximum and median. Calculation of the median is a feature of this program which distinguishes it from other calculator statistics programs. In addition, without having to re-enter the data, the histogram may be calculated with a varying number of cells or a varying cell width.

PROGRAM DESCRIPTION:

The single variable statistics program has entry points for two different techniques of data input. The fastest

method, which provides both an alphanumeric prompt and an audio tone to speed data entry, may be called by execution of the program from entry point "STAT1." A slower method, which provides greater accuracy and suppresses the audio tone for classroom use, may be called by execution of the program from entry point "S1." When called from "S1," the program requires the verification of each data point after entry. The sequence of actions is as follows:

1. The calculator displays an alphanumeric prompt. As an example, "X1?" is the prompt for the first point.
2. The user enters the data value with the digit entry keys and presses the run/stop key.
3. The calculator displays the data entered with a label derived from the alphanumeric prompt. For example, "x1=3.1415" is a typical calculator response. This display is prompting the user to verify the correctness of the data displayed.
4. If the value is correct, then the user simply presses the run/stop key and the calculator advances to the next point.
5. If the value is erroneous, the user enters the correct value with the digit entry keys and then presses the run/stop key. Then the calculator will again repeat step 3 and ask the user to verify the data value. This process will continue until the user makes no modification to the data value.

To run the program from either entry point the user may use the XEQ key, or assign the entry point label ("STAT1" or "S1") to a key and execute it by pressing that key in the USER mode. Further instructions on running programs and making key assignments are contained in the calculator owner's manual [Ref. 2: pp 114-116].

In addition to the two initial entry points described above, several other alphabetic labels provide the user with functions that are called outside the normal sequence of program execution. Label "SR" provides the user with the capability to review the data stored in calculator memory, either before or after the data has been sorted. When used before the sort, the "SR" function is most useful in verifying the entire data set at one time. If used for this purpose, it should be called after all of the data has been entered and the mean of the data set is displayed with the "XBAR" label. If flag 21, the printer enable flag, is set "on" during this data review, then the calculator will stop as each point is displayed and the user may make corrections in the same manner as described above for the point-by-point verification associated with the "S1" entry point. When used after the sort, the "SR" function is most useful for displaying the order statistics for the data set. If used for this purpose, it should be called after the histogram is output--when the "CMD" prompt is displayed. If the user presses run/stop after the "CMD" prompt, the order statistics will automatically be displayed.

The design of the program, especially the data entry loop, reflects the need for calculation speed. Code

redundancy exists at several points in order to reduce the need for extra flags, labels and goto statements which would slow execution during data entry. In spite of this need for speed, the summary totals needed for calculation of mean, standard deviation, skewness and kurtosis are accumulated during data entry. This is done so that these summary statistics are available with little or no wait following data entry.

A complete listing of the program registers and flags used by this program is shown at the end of the program listing.

SAMPLE PROBLEM:

In order to establish a training standard for an obstacle course, a division assistant G3 randomly selects 10 soldiers and records the time it takes each to complete the course. The following times in minutes were recorded:

2.1	2.4	2.2	2.7	2.5
2.4	2.6	2.6	2.3	2.9

Determine the summary statistics and cell frequencies necessary to plot a histogram of this data.

SOLUTION:

1. First, set the size of the calculator's data memory large enough to retain the data values. This requires at least 16 registers plus 1 for each data point, or a total of 26 in this example. Alternatively, the size of data memory may be set arbitrarily large, up to a maximum of 235 provided the user has no other programs in the calculator he wishes to retain. For this example press:

XEQ ALPHA SIZE ALPHA 26

2. To call the program, determine the appropriate method of data entry and select the corresponding entry point. Press:

XEQ	ALPHA	STAT1	ALPHA	(quick entry)
		-or-		
XEQ	ALPHA	S1	ALPHA	(classroom use)

3. The calculator will respond with the prompt "N?" asking for the number of data points. Press:

10 R/S

4. The calculator will respond with the prompt "X1?" asking for the first data point. Press:

2.1 R/S

5. If you called the program via "S1" the calculator will respond with "X1=2.100" asking for verification that the first point is correct. If not correct enter the correct value, else press run/stop.

6. The calculator will continue in the same way as steps 4 and 5 for the remaining data points until all the data has been entered. If at any time you discover that you have made an error in data entry for any point, press:

XEQ ALPHA SC ALPHA

The calculator will respond with the prompt "POINT?" asking for the number of the point in error. For example, if point number 5 were in error, you would then press:

5 R/S

Assuming you had just input a 5 as the point in error, the calculator would then respond with the prompt "X5?" asking for the correct value of point 5. Respond with the correct value and press run/stop. The calculator will then go back to the place in the data entry sequence where it left off or it will go to the calculation of the summary statistics if data entry was previously completed.

7. When data entry has been completed, the calculator will respond with the mean of the data sample labeled as follows:

XBAR=2.470

At this point, you have the option of reviewing the entire data set or continuing to calculate the remainder of the statistics. To review the entire data set, press:

XEQ ALPHA SR ALPHA

Note that if flag 21 is set on (press SF 21), the calculator will stop after each data point is displayed, permitting you to change any value simply by entering the new value and pressing run/stop.

8. After the mean is displayed with the "XBAR" label, if you simply press the run/stop key, the calculator will calculate the following statistics with the label shown: After each press R/S.

Display	Meaning
SSQD=0.521	Sum of Squared Deviations About the Mean
SX=0.241	Sample Standard Deviation
SKEW=0.170	Skewness
KURTO=2.302	Kurtosis

9. At this point the calculator will automatically sort the data. This may take from several seconds to several minutes

depending on the number of points in the data set. After the data set has been sorted, the calculator will display the median as follows:

```
MED=2.400 TO          (Press R/S)
.. 2.500
```

Two data values are displayed because when the number of data points is even, the median is not unique, but rather spans an interval from the one point listed above to the other. Many users may wish to simply take the middle of this interval as the median, but any point is technically correct in the interval. When the number of data points is odd, the median is unique and only one value will be displayed by the calculator.

10. After the median is displayed as described in step 9, the calculator will display the following statistics labeled as shown:

Display	Meaning
MIN=2.100	Minimum Value
MAX=2.900	Maximum value
RNG=0.800	Range

11. At this point the calculator will respond with "CELL?" asking for the number of cells the user desires in the

histogram. If the number of cells is not significant at this point, the calculator will pick an appropriate number if the user simply presses run/stop. For this example, press:

R/S

12. Next the calculator responds with "WIDTH" asking for the width of the cells. Simply press run/stop if you do not wish to establish the width manually. Again, you may see the width the calculator will use by pressing the clear arrow key (Unless the width is an integer, you will also need to press FIX 3 to display the decimal properly if you wish to examine the width.) For this example, press:

R/S

13. The calculator will now display the cell frequency counts as an integer count followed by the next cell boundary. The leftmost cell boundary is set equal to the minimum value and is not explicitly output. If a data point falls exactly on a cell boundary, it is counted in the left cell.

For this example, the display will show:

Display	Meaning
CNT=2	Two observations between 2.1 (the minimum)
xx=2.260	and 2.26 (the cell boundary)
CNT=3	Three observations between 2.26 (see above)
xx=2.420	and 2.42 (the next boundary)
CNT=1	One observation between 2.42 (see above)
xx=2.580	and 2.58 (the next boundary)
CNT=3	Three observations between 2.58 (see above)
xx=2.740	and 2.74 (the next boundary)
CNT=1	One observation between 2.74 (see above)
xx=2.900	and 2.90 (the maximum)

14. After the last cell boundary is displayed, the calculator will display "CMD" asking the user for the next command. Frequently, the user will wish to modify the histogram by changing the number of cells or the cell width. To recalculate the histogram cell frequencies without re-entering the data press:

XEQ ALPHA AGAIN ALPHA

If no further work with the histogram is desired, the user may view the order statistics simply by pressing run/stop.

USER INSRUCTIONS: SINGLE VARIABLE STATISTICS

STEP	EXPLANATION	SEE	PRESS	RESULT
1	SET SIZE (nnn=16+NUMBER OF DATA POINTS)		XEQ "SIZE NNN	UP TO nnn = 235
2	CALL THE PROGRAM ("STAT1 IS FOR REGULAR USE) ("S1 IS FOR CLASSROOM USE)		XEQ "STAT1 -or- "S1	
3	ENTER THE NUMBER DATA POINTS.	N?	input R/S	
4	ENTER THE DATA For mistakes or to review the data see last two steps below. WHEN VERIFY MODE IS SET ON (SET BY FLAG 05 ON), AFTER EACH DATA POINT IS ENTERED, THE VALUE WILL BE ECHOED BACK BY THE CALCULATOR.	X1?, X2? ETC. x1=xx etc.	input R/S R/S -or- correct value	
5	SUMMARY STATISTICS ARE CALCULATED WHEN ALL DATA HAS BEEN ENTERED. STANDARD DEVIATION SKEWNESS KURTOSIS	XBAR=xx SSQD=xx SX=xx SKEW=xx KURT=xx	R/S R/S R/S R/S R/S	mean sum of sq dev from mean	
6	CALCULATOR WILL AUTOMATICALLY SORT DATA POINTS. AND THEN DISPLAY: MEDIAN (note if N is even the median is not unique and an interval is displayed) MINIMUM MAXIMUM RANGE	PRGM MED=xx MIN=xx MAX=xx RNG=xx	 R/S R/S R/S R/S	STANDBY

USER INSRUCTIONS: SINGLE VARIABLE STATISTICS

STEP	EXPLANATION	SEE	PRESS	RESULT
7	USER OPTION TO ENTER NUMBER OF HISTOGRAM CELLS. NO INPUT IS REQUIRED.	CELL?	R/S -or- INPUT N R/S	
8	USER OPTION TO ENTER WIDTH OF HISTOGRAM CELLS. (HAS PRECE-DENCE OVER NUMBER OF CELLS IF A WIDTH IS ENTERED.)	WIDTH?	R/S -OR- INPUT R/S	
9	CALCULATE HISTOGRAM (OUTPUT DATA ABOUT EACH CELL FROM LEFT TO RIGHT.)	CNT=II XX=xx	R/S R/S	CELL FREQ COUNT UPPER X-VALUE LIMIT
10	ACCEPT NEXT COMMAND	CMD	ENTER NEXT CMD	
11	RECALCULATE HISTOGRAM		XEQ "AGAIN	
12	EDIT AN INPUT VALUE AT ANY TIME PRIOR TO DATA SORT. AFTER INPUT OF NEW VALUE CALCULATOR WILL RETURN TO DATA INPUT OR CALCULATION OF SUMMARY STATS AS APPROPRIATE.	 POINT? X?	XEQ "SC INPUT POINT NUMBR INPUT CORRECT VALUE	 WILL REMOVE POINT

USER INSRUCTIONS: SINGLE VARIABLE STATISTICS

STEP	EXPLANATION	SEE	PRESS	RESULT
13	REVIEW DATA POINTS (OR REVIEW ORDER STATS AFTER SORT.)		XEQ "SR	

HP41C SOURCE CODE: SINGLE VARIABLE STATISTICS

```
          ,-----------------------,
          |                       |
          |         STAT1         |
          |                       |
          '-----------------------'
 1 LBL "STAT1          (RECOMMENDED ENTRY POINT
 2 CF 05               (SET VERIFY MODE OFF
 3 SF 26               (ENABLE AUDIO
 4 GTO "SS
          ,-----------------------,
          |                       |
          |         S1            |
          |                       |
          '-----------------------'
 5 LBL "S1             (ENTRY POINT FOR CLASSROOM USE
 6 SF 05               (SET VERIFY MODE ON
 7 CF 26               (DISABLE AUDIO TONES
 8 SF 21               (SET TO STOP DURING VERIFICATION
          ,-----------------------,
          |                       |
          |         "SS           |
          |                       |
          '-----------------------'
 9 LBL "SS             (ENTRY POINT FOR USER SET OPTIONS
10 CF 29               (NO DIGIT GROUPING
11 &REG 10             (ESTABLISH STATISTICAL REGISTERS
12 CF 06               (USED BY DATA REVIEW FUNCTION
13 CF 08               (USED BY DATA EDITING FUNCTION
          ,-----------------------,
          |                       |
          |         00            |   DATA ENTRY (F06-CLEAR)
          |                       |         AND
          |                       |   DATA REVIEW (F06-SET)
          '-----------------------'
14 LBL 00
15 15
16 STO 04             (ESTABLISH INDIRECT ADDRESS BASE REG.
17 STO 00             (INITIALIZE DATA ENTRY POINTER
18 RCL 15             (NUMBER DATA POINTS (LAST PROBLEM)
19 CL&
20 "N?
21 FC? 06             (CLEAR MEANS  DATA ENTRY,NOT REVIEW
22 PROMPT
23 1E3
24 /
25 1
26 +
27 STO 01             (SET UP LOOP COUNTER FOR DATA POINTS
```

HP41C SOURCE CODE: SINGLE VARIABLE STATISTICS

```
                    01                  DATA ENTRY LOOP

28 LBL 01
29 ISG 00                   (INCREMENT DATA STORAGE POINTER
30 LBL 02
31 RCL IND 00               (RECALL DATA VALUE
32 "X
33 FIX 0
34 ARCL 01
35 FIX 3
36 ASTO 03                  (TEMP STORAGE FOR LABEL
37 FS? 06                   (IS THIS REVIEW OF DATA PREV. ENTERED?
38 GTO 03
39 "→=?
40 TONE 9                   (PROMPT USER FOR NEXT DATA VALUE
41 PROMPT
42 STO IND 00               (STORE THE DATA VALUE
43 FC? 05                   (NO VERIFICATION OF DATA DESIRED?
44 GTO 04
45 LBL 03                   (FOLLOWING IS THE VERIFICATION ROUTINE
46 CLA
47 ARCL 03                  (RECALL THE LABEL
48 "→=
49 ARCL IND 00              (RECALL THE STORED DATA
50 CF 22                    (CLEAR DATA ENTRY FLAG
51 AVIEW                    (WILL STOP FOR DATA ENTRY IF F21 SET
52 FC? 22                   (WAS THERE NO DATA CHANGE DURING VIEW?
53 GTO 04
54 STO IND 00               (IF THERE WAS A NEW VALUE, THEN RECORD
55 GTO 03                   (IT AND GOBACK AND RE-VERIFY THE DATA.
56 LBL 04                   (FOLLOWING IS THE STATISTICAL ACCUM.
57 ST+ 10                   (STORES SIGMA X
58 X|2
59 ST+ 11                   (STORES SIGMA X-SQUARED
60 LASTX
61 *
62 ST+ 12                   (STORES SIGMA X-CUBED
63 LASTX
64 *
65 ST+ 13                   (STORES SIGMA X-FOURTH-POWER
66 FS? 08                   (IS THIS A DATA REVIEW?
67 RTN
68 ISG 01                   (IF DATA ENTRY, INCREMENT INPUT CNTR.
69 GTO 01
70 RCL 01                   (AT END OF DATA ENTRY, RECALL INPUT
                             (COUNTER, WHICH IS A NUMBER EQUAL ONE
                             (MORE THAN NUMBR POINTS
```

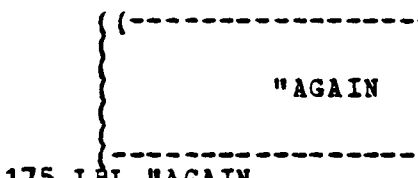
"SM — CALCULATION OF SUMMARY STATS

```
LBL "SM          (ENTRY ASSUMES X-REGISTER HAS A NUMBR
INT              (1 MORE THAN NUMBER OF DATA POINTS.
1
-
STO 15           (STORES THE NUMBER OF DATA POINTS
MEAN
"XBAR
XEQ 97           (CALL AN OUTPUT LABELING ROUTINE
STO 03           (TEMP STORE FOR XBAR
RCL 11           (RECALL SIGMA X-SQUARED
RCL 03           (RECALL XBAR
X|2
RCL 15           (RECALL NUMBR POINTS
*
-
STO 09           (TEMP STORE FOR SUM OF SQUARED
"SSQD               (DEVIATIONS ABOUT THE MEAN
XEQ 97
RCL 15           (NUMBER POINTS
1
-                (CAN NOT USE SDEV FUNCTION BECAUSE OF
/                   (NON-STANDARD USE OF REGISTERS 12-14
SQRT
"SX              (STANDARD DEVIATION
XEQ 97
RCL 09           (SUM OF SQ DEVIATION ABOUT MEAN
RCL 15           (NUMBER POINTS
/
STO 05           (SECOND MOMENT
RCL 12           (SIGMA X-CUBED
RCL 11           (SIGMA X-SQUARED
RCL 03           (XBAR
*
3
*
-
RCL 15           (NUMBER POINTS
/
RCL 03           (XBAR
3
Y|X
2
*
+
STO 06           (THIRD MOMENT
RCL 05           (SECOND MOMENT
1.5
Y|X
/
"SKEW
XEQ 97           (OUTPUT THE SKEWNESS OF THE DATA
RCL 13           (SIGMA X-FOURTH-POWER
RCL 12           (SIGMA X-CUBED
RCL 03           (XBAR
```

HP41C SOURCE CODE: SINGLE VARIABLE STATISTICS

```
125 *
126 4
127 *
128 -
129 RCL 03              (XBAR
130 X|2
131 RCL 11              (SIGMA X-SQUARED
132 *
133 6
134 *
135 +
136 RCL 15              (NUMBER POINTS
137 /
138 RCL 03              (XBAR
139 4
140 Y|X
141 3
142 *
143 -
144 STO 07              (FOURTH MOMENT
145 RCL 05              (SECOND MOMENT
146 X|2
147 /
148 "KURT=
149 XEQ 97              (OUTPUT THE KURTOSIS
    (FS? 09              (SHORT FORM WOULD NOT COMPUTE STATS
    )RTN                    (WHICH REQUIRE SORTED DATA
150 XEQ 98              (CALL A DATA SORTING ROUTINE
151 CF 00               (INITIALIZE TEMP FLAG USED TO CHECK
152 RCL 15                 (EVEN OR ODD NUMBER OF DATA POINTS
153 2
154 /
155 FRC
156 X=0?                (WAS IT AN EVEN NUMBER OF POINTS?
157 SF 00               (IF WAS EVEN NUMBER, SET FLAG.
158 LASTX
159 .5                  (COMPUTING ADDRESS OF MEDIAN
160 +
161 RCL 04              (ADDRESS BASE REGISTER
162 +                   (X-REG NOW HAS ADDRESS OF MEDIAN
163 "MED=
164 ARCL IND X
165 FC? 00              (EVEN NUMBER POINTS IMPLIES THE MEDIAN
166 GTO 05                (NOT UNIQUE,BUT SPANS AN INTERVAL
167 "¬ TO
168 PROMPT              (DISPLAY THE LEFT BOUNDARY OF MEDIAN
169 1
170 +                   (X-REG POINTS TO RIGHT BOUND OF MEDIAN
171 ".. "
172 ARCL IND X
173 LBL 05
174 PROMPT
```

HP41C SOURCE CODE: SINGLE VARIABLE STATISTICS




```
175 LBL "AGAIN
176 RCL 04              (ADDRESS BASE REGISTER
177 1
178 +
179 RCL IND X           (RECALL THE FIRST ORDER STAT
180 "MIN
181 XEQ 97              (CALL AN OUTPUT LABELING ROUTINE
182 STO 09              (HOLDS STARTING (LEFTMOST) X BOUNDARY
183 RCL 04              (ADDRESS BASE REGISTER
184 RCL 15              (NUMBER OF DATA POINTS
185 +
186 RCL IND X           (RECALL THE N-TH ORDER STATISTIC
187 "MAX
188 XEQ 97              (DISPLAY THE MAX VALUE OBSERVED
189 RCL Z               (MIN
190 -
191 STO 08              (TEMP STORE FOR THE RANGE
192 "RNG
193 XEQ 97              (DISPLAY THE RANGE
194 CF 00               (INITIALIZE TEMP FLAG TO MARK LAST BAR
195 RCL 15              (NUMBER DATA POINTS
196 RCL 04              (ADDRESS BASE REGISTER
197 +
198 1E3
199 /                   (COMPUTING INDEX LOOP COUNTER
200 RCL 04              (ADDRESS BASE REGISTER
201 +
202 1
203 +
204 STO 01              (R01 SET TO ADDRESS AND LOOP THRU DATA
205 RCL 15              (NUMBER POINTS
206 LN
207 2
208 *                   (DEFAULT NUMBER OF BARS IS 2*LN(N)
209 FIX 0
210 RND                 (VALUE IS ROUNDED NOT TRUNCATED
211 "CELL?
212 PROMPT              (USER HAS OPTION TO CHNGE NUMBR CELLS
213 RCL 08              (RANGE
214 X<>Y
215 /
216 "WIDTH
217 PROMPT              (USER HAS OPTION TO CHANGE CELL WIDTH
218 STO 08              (NOW HOLDS CELL WIDTH NOT RANGE
219 LBL 06
220 RCL 08              (CELL WIDTH
221 ST+ 09              (UPPER LIMIT OF CURRENT CELL COUNTED
222 0
223 STO 02              (INITIALIZE CELL COUNTER
224 LBL 07
225 RCL IND 01          (NEXT DATA POINT
226 RCL 09              (CELL UPPER LIMIT
227 FIX 3
228 RND
```

HP41C SOURCE CODE: SINGLE VARIABLE STATISTICS

```
229 X<Y?                    (DATA POINT LESS THAN UPPER LIMIT
230 GTO 08
231 1
232 ST+ 02                  (INCREMENT THE CELL COUNTER
233 ISG 01                  (PREPARE TO LOOK AT NEXT DATA POINT
234 GTO 07
235 SF 00                   (SET FLAG FOR OUTPUT OF LAST BAR
236 LBL 08
237 "CNT
238 RCL 02
239 FIX 0
240 XEQ 97                  (OUTPUT THE CELL FREQUENCY COUNT
241 FIX 3
242 "XX
243 RCL 09
244 XEQ 97                  (OUTPUT CELL BOUNDARY--LOWER LIMIT
245 FC?C 00                 (IS THIS THE LAST BAR ?
246 GTO 06
247 "CMD
248 AVIEW
249 RTN
```

HP41C SOURCE CODE: SINGLE VARIABLE STATISTICS

```
      ┌──────────────────────┐
      │                      │
      │        "SR           │   REVIEW THE DATA
      │                      │
      └──────────────────────┘
250 LBL "SR
251 SF 06              (SETS MODE FOR REVIEW NOT QUERY
252 GTO 00
      ┌──────────────────────┐
      │                      │
      │        "SC           │    EDIT THE DATA
      │                      │
      └──────────────────────┘
253 LBL "SC
254 SF 08              (SET TO EDIT MODE
255 CF 06              (SET TO QUERY FOR CORRECT VALUE
256 RCL 00             (CURRENT INPUT ADDRESS POINTER
257 STO 05             (SAVE TO ENABLE RETURN TO DATA ENTRY
258 RCL 01             (CURRENT INPUT INDEX LOOP COUNTER
259 STO 06             (SAVE TO ENABLE RETURN TO DATA ENTRY
260 "POINT?
261 PROMPT
262 STO 01             (ESTABLISH PSEUDO-INDEX COUNTER
263 RCL 04             (ADDRESS BASE REGISTER
264 +
265 STO 00             (COMPUTED ADDRESS OF DATA TO BE EDITED
266 RCL IND 00         (RECALL THE OLD VALUE
267 ST- 10             (CORRECT SIGMA X
268 X|2
269 ST- 11             (CORRECT SIGMA X-SQUARED
270 LASTX
271 *
272 ST- 12             (CORRECT SIGMA X-CUBED
273 LASTX
274 *
275 ST- 13             (CORRECT SIGMA X-FOURTH-POWER
276 XEQ 02             (CALL DATA ENTRY AS A SUBROUTINE
277 CF 08              (FOLLOWING RESTORES DATA ENTRY
278 RCL 05             (INPUT ADDRESS REGISTER VALUE
279 STO 00
280 RCL 06             (INPUT LOOP COUNTER
281 STO 01
282 1
283 -
284 ISG X              (TEST TO SEE IF ALL DATA ALREADY INPUT
285 GTO 02             (IF NOT, BRANCH TO THE INPUT LOOP
286 GTO "SM            (IF YES, RECOMPUTE THE SUMMARY STATS
```

HP41C SOURCE CODE: SINGLE VARIABLE STATISTICS

```
        {(----------------------)
        {                      }
        {          97          }      OUTPUT LABELING ROUTINE
        {                      }
        {----------------------}
287 LBL 97
288 "="
289 ARCL X
290 PROMPT
291 RTN
```

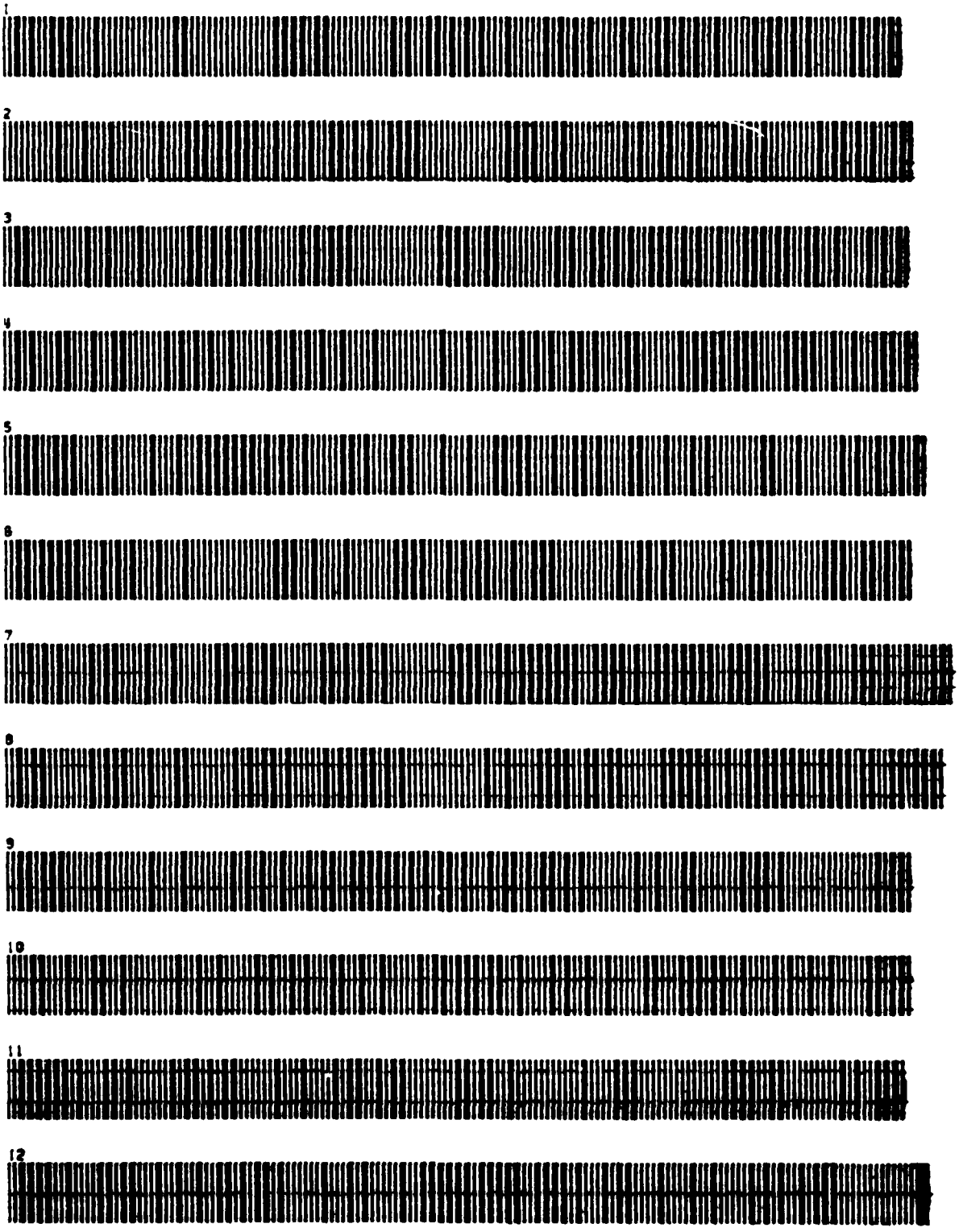
HP41C SOURCE CODE: SINGLE VARIABLE STATISTICS

```
                (----------------------)
                |                      |
                |          98          |        SHELL SORT
                |                      |
                (----------------------)
292 LBL 98
293 RCL 15              (RECALL NUMBER OF DATA POINTS
294 STO 01              (DEFINE A = "MIDPOINT"
295 LBL 09
296 RCL 01              (RECALL MIDPOINT
297 2
298 /
299 INT
300 STO 01              (A = INT(A/2)
301 X=0?                (TEST TO SEE IF LIST SORTED
302 RTN
303 1
304 STO 02              (B = 1  -- RESET LEFT SHELL BOUNDARY
305 LBL 10              |   STACK TABLE FOLLOWS:
306 STO 03              |   C=B       B
307 LBL 11              |   C         B
308 RCL 01              |   A         C          B
309 +                   |   D=C+A     B
310 RCL 04              |   BASE      D          B
311 +                   |   ADDR D    B
312 RCL IND X           |   X(D)      ADDR D     B
313 RCL 03              |   C         X(D)       ADDR D ,B
314 RCL 04              |   BASE      C          X(D)   ,ADDR D
315 +                   |   ADDR C    X(D)       ADDR D
316 X<>Y                |   X(D)      ADDR C     ADDR D
317 RCL IND Y           |   X(C)      X(D)       ADDR C ,ADDR D
318 X<=Y?
319 GTO 12              (FOLLOWING INTERCHANGES X(C) AND X(D)
320 STO IND T           |   X(C)      X(D)       ADDR C ,ADDR D
321 X<>Y                |   X(D)      X(C)       ADDR C ,ADDR D
322 STO IND Z           |   X(D)      X(C)       ADDR C ,ADDR D
323 RCL 03              |   C
324 RCL 01              |   A         C
325 -                   |   C=C-A
326 STO 03              |   C
327 X>0?
328 GTO 11
329 LBL 12
330 RCL 15              |   N
331 RCL 01              |   A         N
332 -                   |   E=N-A
333 RCL 02              |   B         E
334 1                   |   1         B          E
335 +                   |   B+1       E
336 STO 02              |   B=B+1     E
337 X<=Y?
338 GTO 10
339 GTO 09
```

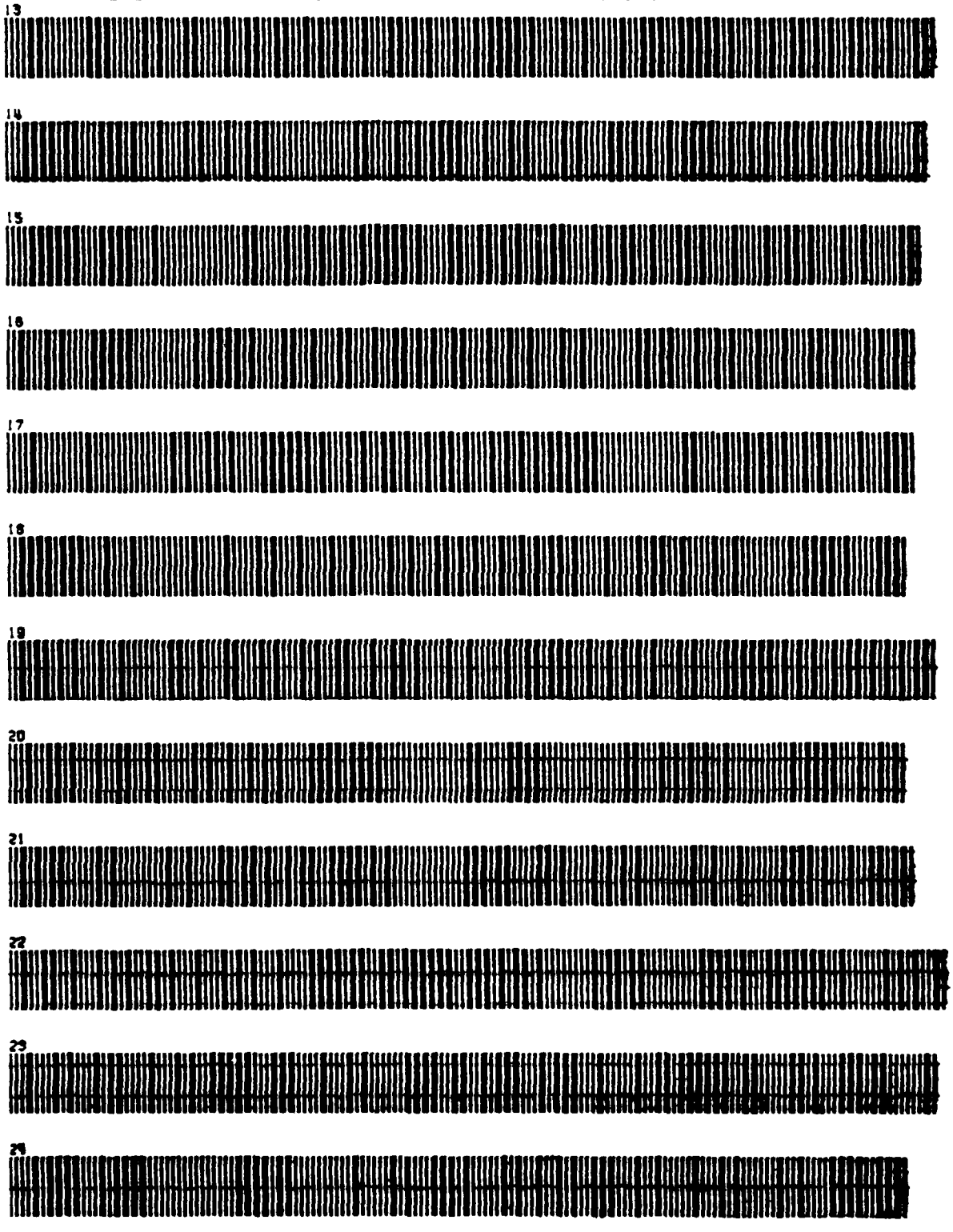
HP41C SOURCE CODE: SINGLE VARIABLE STATISTICS

```
{(
      THIS PROGRAM USES THE FOLLOWING REGISTERS:

            R00 -- INPUT DATA ADDRESS POINTER
            R01 -- LOOP INDEX COUNTER
                   (USED BY DATA ENTRY AND SORT ROUTINES)
            R02 -- TEMP REGISTER
                   (CELL FREQUENCY COUNT IN HISTO RTN)
                   (AND SHELL BOUNDARY IN SORT ROUTINE)
            R03 -- TEMP REGISTER
                   (INPUT LABEL IN DATA INPUT ROUTINE)
                   (XBAR IN SUMMARY STAT ROUTINE)
                   (AND  POINTER IN SORT ROUTINE)
            R04 -- INDIRECT ADDRESS BASE
            R05 -- SECOND MOMENT (POPULATION VARIANCE)
            R06 -- THIRD MOMENT
            R07 -- FOURTH MOMENT
            R08 -- HISTOGRAM CELL WIDTH
            R09 -- TEMP REGISTER
                   (HOLDS SUM OF SQ DEVIATION ABOUT MEAN)
                   (AND HISTOGRAM CELL UPPER LIMIT)
            R10 -- SUM OF X VALUES
            R11 -- SUM OF X-SQUARED VALUES
            R12 -- SUM OF X-CUBED VALUES
            R13 -- SUM OF X RAISED TO THE FOURTH POWER
            R14 -- NOT USED BUT SET TO ZERO BY CLR&
            R15 -- NUMBER DATA POINTS (SET BY &+)
            R16....R228 RAW DATA POINTS
                     -- IN NATURAL SEQUENCE BEFORE SORT
                     -- AS ORDER STATISTICS AFTER SORT

      THIS PROGRAM USES THE FOLLOWING FLAGS:

            F00 -- TEMP FLAG (USED IN EDIT AND HISTO RTNS)
            F05 -- VERIFY MODE (EVERY DATA POINT ECHOED)
            F06 -- INDICATES REVIEW OF DATA NOT QUERY MODE
            F08 -- INDICATES EDITING A DATA POINT
            F21 -- PRINTER ENABLE (STOPS CALCULATOR
                      DURING AVIEW INSTRUCTION)
            F26 -- AUDIO ENABLE
340 END
```

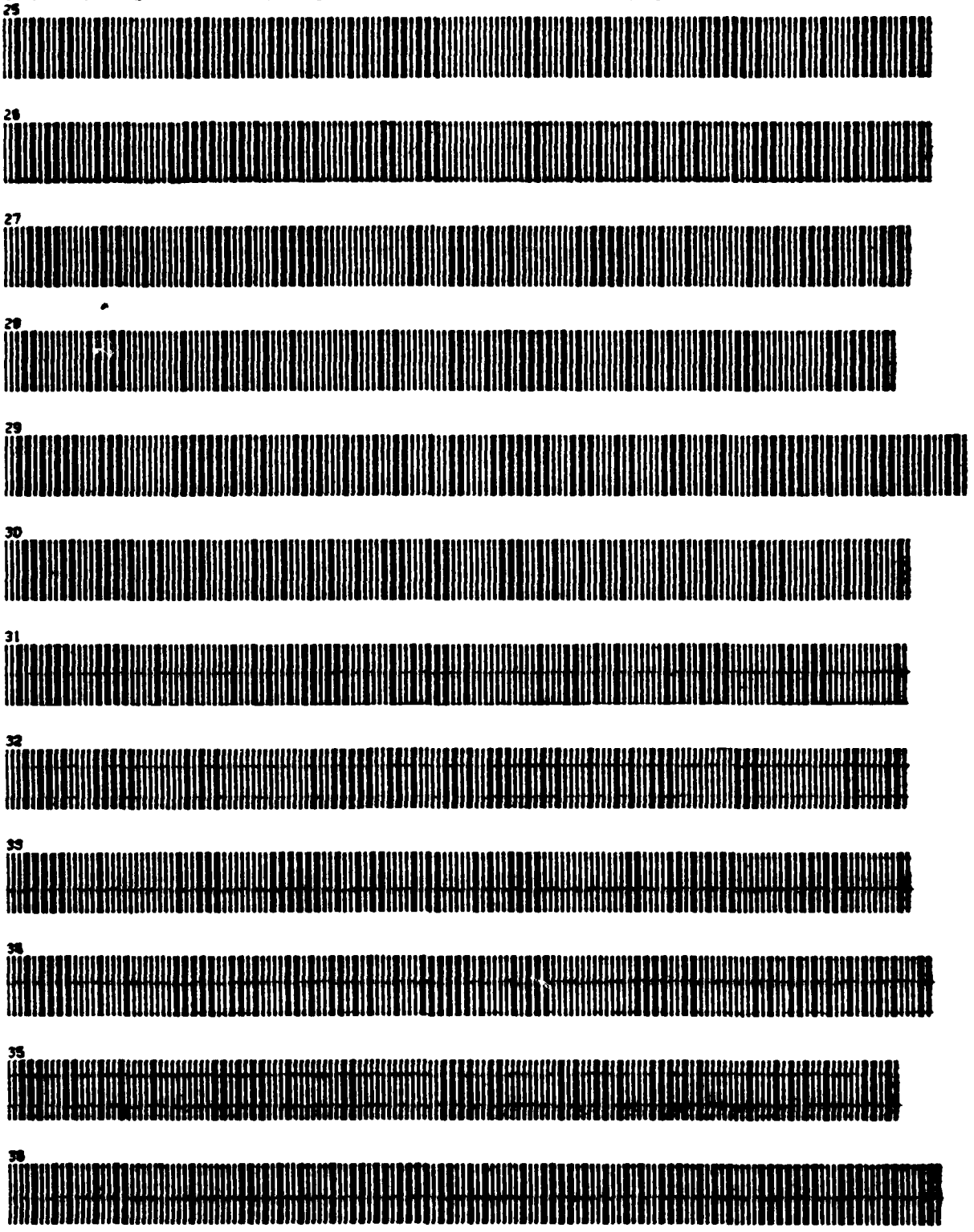
SINGLE VARIABLE STATISTICS



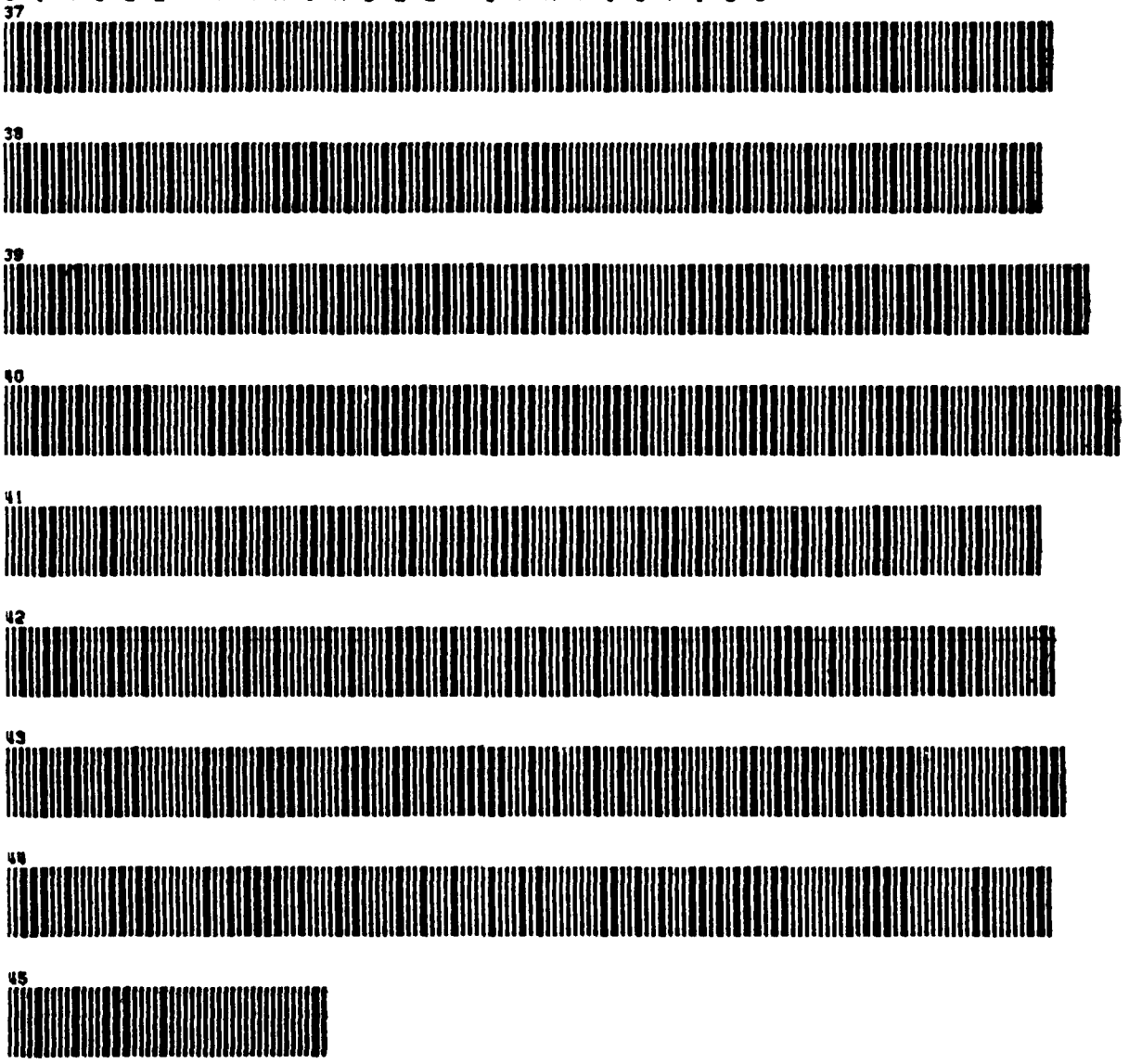
SIMGLE VARIABLE STATISTICS



SINGLE VARIABLE STATISTICS



SINGLE VARIABLE STATISTICS



APPENDIX B

LINEAR PROGRAMMING EXAMPLE

INTRODUCTION:

Linear programming is an operations research technique normally associated with computerized data bases and the largest computers. Because of the complexity of the computer programs for linear programming and the large amount of data associated with most real world problems, calculators have not been widely used for this application. With the increased memory capacity of the HP41CV, however, it is now possible to offer a calculator program which can solve interesting small scale linear programs. Of value primarily as an educational aid, this program will also be able to solve many small scale problems found at Army division, brigade and battalion level. The text by Hillier and Lieberman [Ref. 8: pp. 16-66] is recommended as an introduction to the theory of linear programming as used by the program given in this appendix. Use of the program requires the user to formulate the linear programming problem; set up a Simplex tableau in standard form including adding slack, surplus and artificial variables as required; and interpret

the final tableau including the calculation of the values associated with the variables in the final basis. Using the tableau form of the Simplex algorithm, the calculator performs both phase I (to obtain a feasible solution) and phase II (to obtain an optimal solution) to solve the linear programming problem. The calculator automatically determines the pivot column and pivot row for each pivot step. Infeasible and unbounded problems are automatically identified for the user by the program. There is no explicit handling of variables with upper bounds.

PROGRAM DESCRIPTION:

The program is written as a series of subroutines, each of which performs a major step in the Simplex algorithm. To provide clarity to the user, alphabetic labels have been retained to identify the subroutines in lieu of faster and more memory efficient numeric labels. The alphabetic labels have not been retained for use as program entry points and may be changed to numeric labels at the option of the user. The program has two entry points, "LP" for running a new problems and "ALP" for reviewing data previously entered.

Subroutine "FINDQ" determines the pivot column by selecting the variable in the objective function with the most negative "price." If "FINDQ" discovers at least one

negative value in the objective function, then the tableau column number associated with the most negative value will be stored in register 05. Upon return from "FINDQ," the main routine tests register 05 to see if it contains a non-zero entry. If the entry is zero, it means that no further pivots will improve the value of the objective function, and the Simplex algorithm halts. If the program was in phase I (flag 11 clear) and the value of the phase I objective function is reduced to zero, then a feasible solution has been found and the program will automatically proceed to phase II to discover an optimal solution.

Subroutine "FINDP" determines which variable will leave the current basis by performing a minimum positive ratio test along the pivot column. In this way, the pivot row is determined. The row number of the pivot row is stored in register 06. Upon return from subroutine "FINDP," the main routine tests register 06 to see if it contains a non-zero entry. If the entry is zero, it means that the problem is unbounded and the Simplex algorithm halts. Such an unbounded condition is most likely caused by an error in the problem formulation.

Having determined the pivot column and the pivot row, subroutine "PIVOT" performs the actual Simplex pivot

operation. To speed calculation register 00 is used as a temporary register to hold the reciprocal of the pivot element. Note that the pivot row is handled separately from the other rows in the tableau. Flag 04 is used to provide the option of stopping calculation after every pivot. When this flag is set, the program will halt to allow the user to review the status of the tableau with the "ALP" function.

Subroutine "CHECK" has two primary functions. First, it is used to verify that the designated basic variables are in row elimination form prior to the start of the Simplex algorithm. This means that the basic variable must have a coefficient of 1 in the row in which it is basic and zero's in all other rows. The second function of check is to prepare the objective function for phase I, if the initial basis contains artificial variables as indicated by one or more minus signs in the "JB" vector.

Three subroutines are used to query the user for input data. Subroutine "READMN" queries the user for the number of constraints and decision variables in the problem and verifies the calculator memory is set to contain all the data necessary to solve the problem. Subroutine "READJB" queries the user for a column vector of pointers which indicate which variable is currently basic in each row. When

entering this vector of pointers, the user indicates artificial variables with a minus sign. Subroutine "READA" queries the user for the values in the initial Simplex tableau including the slack and surplus variables and the right hand side and objective function.

Several other service routines also are provided in this program. Memory size verification is done by subroutine "SIZE," which is called from within "READMN." Subroutine "IN" is used to query the user for data entry and is called by all of the data input routines. Subroutine "NXT" initializes registers which contain frequently used quantities such as the the total size of the tableau for phase I and phase II. Subroutine "INIT" clears the calculator memory and sets flags and program constants appropriately for input of a new problem. Subroutine "SETL" establishes the loop counters used repeatedly within almost every other subroutine. Subroutine "ERR1" displays an appropriate error message if a data entry error is detected.

SAMPLE PROBLEM:

A division assistant G4 is planning an ammunition upload plan. There are four types of tank munitions to consider,

including:

A = Discarding Sabot Rounds
B = High Explosive Anti-Tank Rounds
C = Phosphorous Munitions
D = Machine Gun Ammunition

Based on the Commander's guidance the assistant G4 is to consider the sabot rounds as twice as important as the HEAT rounds, which in turn are themselves twice as important as a unit amount of phosphorous munitions and machine gun ammunition. His mission then, is to maximize:

$$Z = 4A + 2B + C + D$$

He is, however, constrained by the following factors:

1. There can be no more than 30 units of both sabot and HEAT munitions combined.
2. There can be no more than 50 units of all types of ammunition combined.
3. There must be at least 30 units of HEAT and phosphorous munitions combined.
4. There must be at least 5 units of machine gun ammunition.

These constraints may be expressed as:

$$\begin{aligned} A + B &\leq 30 \\ A + B + C + D &\leq 50 \\ B + C &\geq 30 \\ D &\geq 5 \end{aligned}$$

Based on the Commander's guidance and the constraints listed above, formulate an optimum load plan. Fractional units are permitted.

SOLUTION:

1. Before beginning with the calculator, the first step is to layout the tableau in standard form. This step and the last step of interpreting the final tableau require working knowledge of linear programming as explained in Hillier and Liberman [Ref. 8: pp. 16-66]. The standard form of the tableau is:

1	2	3	4	5	6	7	8	9	10	11
A	B	C	D	H1	H2	S1	S2	A1	A2	RHS
1	1					1				30
1	1	1	1				1			50
	1	1		-1				1		30
			1		-1				1	5
-4	-2	-1	-1							0

In this tableau, H1 and H2 are surplus variables; S1 and S2 are slack variables; and A1 and A2 are artificial variables.

2. The first step with the calculator is to set the size of the calculator's data memory. This program requires 20 registers for temporary storage, 1 register for each tableau element, and 1 register for each row to hold the pointer to the basic variable for that row. Thus, if M is the number of constraints and N is the number of variables including slack, surplus and artificial variables, then the total data

storage requirement is:

storage required = 21 + M + ((N + 1) x (M + 2))

As mentioned in the program description, the "SIZE" subroutine will automatically verify that the user has allocated enough data storage to solve the problem. The length of the program is such that 177 data storage registers is the maximum number of data storage registers that can be allocated. Thus, linear programs with 7 constraints and 15 decision variables can be solved with this program. For this example, press:

XEQ ALPHA SIZE ALPHA 175

3. Call for execution of the program with a new data set. Press:

XEQ ALPHA LP ALPHA

4. The calculator will respond with the prompt "NUM ROWS?" asking for the number of constraints in the linear program formulation. In this example, press:

4 R/S

5. The calculator will respond with the prompt "NUM COLS?" asking for the number of variables in the problem. The user

must count the number of slack, surplus and artificial variables in this total. In this example, press:

10 R/S

6. The calculator will respond with the prompt "BASIC 1 ?" asking for the variable number of the variable which is basic in the first row. One of the major features of this program is that the basic variables need not be in the rightmost positions in the tableau. Thus, if a tableau were given in which some pivots had already been performed, the program could resume operation immediately. In this example, press:

7 R/S

In a similar fashion, the calculator will then query the user for the variable number of the variables which are basic in the remaining rows.

For this example:

See	Respond With
Basic 2 ?	8 R/S
Basic 3 ?	9 CHS R/S
Basic 4 ?	10 CHS R/S

Notice that because the basic variables in rows three and four are artificial variables, the variable number is entered as a negative number. This signals the calculator

that these variables must be driven from the basis in order to reach an initial feasible solution.

7. Next, the calculator will respond with "T1,1?" asking for the first element in the tableau. The user should enter the numbers in the tableau using the digit entry keys and pressing run/stop after every entry. Notice that the right hand side and the objective function will be entered with the appropriate index in the tableau as shown in step 1 above. The user must insure that the objective function is in standard form with the appropriate sign for each coefficient--in this example each coefficient is negative.

8. After the last element in the tableau has been entered, the calculator will begin to automatically perform the Simplex algorithm. If the user wishes to stop the calculator after every pivot, he may at any time press:

R/S SF 04 R/S

If this flag is set, the calculator will stop and display the pivot number after every pivot is completed.

9. When the Simplex algorithm can no longer improve the objective function, the calculator will stop and display the value of the objective function. In this example, the

calculator will stop after approximately three minutes and display:

VALUE=110.000

10. At this point, the user must use entry point "ALP" to determine the status of the final tableau. For this example, press:

XEQ ALPHA ALP ALPHA

Then by sequentially pressing the run/stop and clear arrow keys, the basic variables and tableau entries will be displayed. For example, in this problem:

See	Press	See	Meaning
BASIC 1?	CLX	2	Variable 2 is basic in the first row.
BASIC 2?	CLX	1	Variable 1 is basic in the second row.
etc.			

Then for the elements of the tableau:

See	Press	See	Meaning
T1,1?	CLX	0.000	Tableau entry
T1,2?	CLX	1.000	Tableau entry

11. After the calculator is finished, it remains for the user to interpret the final tableau. Again, the reference by Hillier and Lieberman [Ref. 8: pp. 16-66] is of primary value. In particular, the user must be able to determine the value of the final decision variables based upon what

variables are in the basis, and what the final "right hand side" values are for each row. For this example, the final tableau is:

1 A	2 B	3 C	4 D	5 H1	6 H2	7 S1	8 S2	9 A1	10 A2	11 RHS
	1			-1	-1	1	-1	1	1	15
1				1	1		1	-1	-1	15
		1			1		1		-1	15
			1		-1				1	5
0	0	0	0	2	2	1	3	-2	-2	110

Thus, the solution may be interpreted as 15 units each for munitions A,B and C and 5 units for munition D.

USER INSRUCTIONS: LINEAR PROGRAMMING

STEP	EXPLANATION	SEE	PRESS	RESULT
1	SET SIZE (NNN= 21+M+(N+1)(M + 2) WHERE M=NUM ROWS AND N=NUM COLS		XEQ "SIZE NNN	UP TO MIN = 177
2	CALL THE PROGRAM		XEQ "LP	
3	ENTER THE NUMBER OF CONSTRAINTS	NUM ROW ?	INPUT M R/S	
4	ENTER THE NUMBER OF VARIABLES (INCLUDE SLACKS, SURPLUS & ARTIF.	NUM COL ?	INPUT N R/S	
5	ENTER CURRENT BASIC VARIABLE NUMBERS BY ROW	BASIC 1 ? ETC.	INPUT VAR # R/S	
6	ENTER TABLEAU VALUES. FOR MISTAKES OR TO REVIEW THE DATA SEE LAST STEP BELOW.	T1,1? ETC.	INPUT R/S	
7	TO FORCE THE CALCULATOR TO STOP AFTER EACH PIVOT.		R/S SF 04 R/S	
8	SIMPLEX COMPLETED: OPTIMAL SOLUTION FOUND.	VALUE= XX.XXX		FINAL OBJ. FUNCTION VALUE
9	SIMPLEX COMPLETED: PROBLEM IS INFEASIBLE.	INFEAS		

STEP	EXPLANATION	SEE	PRESS	RESULT
10	SIMPLEX COMPLETED: PROBLEM IS UNBOUNDED.	UNBOUND		
11	TO REVIEW VALUES IN TABLEAU AT ANY TIME, INCLUDING FINAL TABLEAU. AS PROMPTS APPEAR, DATA CAN BE CHANGED BY ENTERING NEW VALUE.		XEQ "ALP	
	WHAT IS CURRENTLY BASIC?	BASIC 1 ? ETC.	CLX	PROMPT WILL VANISH LEAVING DATA
	WHAT ARE VALUES IN TABLEAU? OBTAIN VALUES OF FINAL SOLUTION FROM KNOWING WHICH VARS ARE BASIC AND VALUE OF RIGHT-HAND-SIDE FROM THE TABLEAU.	T1,1? ETC.	CLX	PROMPT WILL VANISH LEAVING DATA

HP41C SOURCE CODE: LINEAR PROGRAMMING

```
                    "LP
 1 LBL "LP
 2 XEQ "INIT
 3 LBL "ALP
 4 XEQ "READMN
 5 XEQ "READJB
 6 XEQ "READA
 7 XEQ "CHECK
 8 LBL 15
 9 XEQ "FINDQ
10 RCL 05
11 X#0?
12 GTO 35
13 FS? 11
14 GTO 25
15 RCL 04
16 RCL 10
17 RCL 12
18 *
19 +
20 RCL 07
21 RCL IND Y
22 ABS
23 X<Y?
24 GTO 20
25 "INFEAS
26 AVIEW
27 STOP
28 LBL 20
29 SF 11
30 RCL 04
31 RCL 08
32 RCL 12
33 *
34 +
35 STO 14
36 GTO 15
37 LBL 25
38 RCL 04
39 RCL 09
40 RCL 12
41 *
42 +
43 RCL IND X
44 STO 00
45 "VALUE=
46 ARCL 00
47 AVIEW
48 STOP
49 LBL 35
50 XEQ "FINDP
51 RCL 06
52 X#0?
53 GTO 40
54 "UNBOUND
```

```
55 ARCL 05
56 STOP
57 LBL 40
58 XEQ "PIVOT
59 GTO 15
```

```
      {(----------------------)
      {                      }
      {                      }
      {        FINDQ         }
      {                      }
      {                      }
      {----------------------}
 60 LBL "FINDQ
 61 SF 01
 62 0
 63 STO 03
 64 STO 05
 65 1
 66 RCL 11
 67 XEQ "SETL
 68 LBL 31
 69 RCL 14
 70 RCL 01
 71 +
 72 STO 00
 73 RCL IND X
 74 RCL 03
 75 -
 76 RCL 07
 77 CHS
 78 X<Y?
 79 GTO 38
 80 FC? 11
 81 GTO 37
 82 RCL 15
 83 RCL 01
 84 +
 85 RCL IND X
 86 ABS
 87 RCL 07
 88 X<=Y?
 89 GTO 38
 90 LBL 37
 91 RCL IND 00
 92 STO 03
 93 RCL 01
 94 INT
 95 STO 05
 96 LBL 38
 97 ISG 01
 98 GTO 31
 99 CF 01
100 RTN
```

FINDP

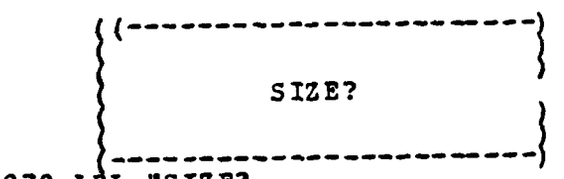
```
101 LBL "FINDP
102 SF 02
103 0
104 STO 06
105 1E20
106 STO 03
107 1
108 RCL 08
109 XEQ "SETL
110 LBL 41
111 RCL 01
112 1
113 -
114 RCL 12
115 *
116 RCL 04
117 +
118 STO 00
119 RCL 05
120 +
121 RCL IND X
122 STO 02
123 RCL 07
124 X>Y?
125 GTO 48
126 RCL 00
127 RCL 12
128 +
129 RCL IND X
130 RCL 02
131 /
132 STO 00
133 RCL 03
134 -
135 RCL 07
136 CHS
137 X<Y?
138 GTO 48
139 LBL 47
140 RCL 00
141 STO 03
142 RCL 01
143 INT
144 STO 06
145 LBL 48
146 ISG 01
147 GTO 41
148 CF 02
149 RTN
```

```
      {(----------------------}
      {                      }
      {        PIVOT         }
      {                      }
      {----------------------}
150 LBL "PIVOT
151 SF 03
152 RCL 06
153 1
154 -
155 RCL 12
156 *
157 RCL 04
158 +
159 STO 03
160 RCL 05
161 +
162 RCL IND X
163 1/X
164 STO 00
165 1
166 RCL 12
167 XEQ "SETL
168 LBL 51
169 RCL 03
170 RCL 01
171 +
172 RCL 00
173 ST* IND Y
174 ISG 01
175 GTO 51
176 1
177 RCL 09
178 FS? 11
179 0
180 FC? 11
181 1
182 +
183 XEQ "SETL
184 LBL 52
185 RCL 06
186 RCL 01
187 INT
188 X=Y?
189 GTO 59
190 1
191 -
192 RCL 12
193 *
194 RCL 04
195 +
196 STO 16
197 RCL 05
198 +
199 RCL IND X
200 STO 00
201 2
202 RCL 12
203 XEQ "SETL
```

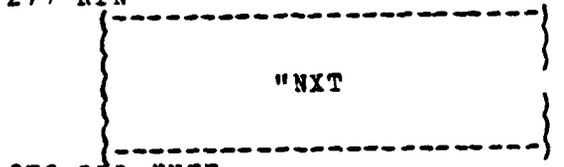
```
204 LBL 53
205 CF 07
206 RCL 05
207 RCL 02
208 INT
209 X=Y?
210 SF 07
211 RCL 03
212 +
213 RCL IND X
214 RCL 00
215 *
216 RCL 16
217 RCL 02
218 +
219 X<>Y
220 ST- IND Y
221 FC? 07
222 GTO 54
223 0
224 STO IND Z
225 LBL 54
226 ISG 02
227 GTO 53
228 LBL 59
229 ISG 01
230 GTO 52
231 RCL 13
232 RCL 06
233 +
234 RCL 05
235 STO IND Y
236 1
237 ST+ 17
238 CF 03
239 TONE 7
240 FC? 04
241 RTN
242 "PIVOT "
243 ARCL 17
244 PRCHPT
245 RTN
```

READMN

```
246 LBL "READMN
247 7
248 STO 00
249 "NUM ROWS
250 XEQ "IN
251 XEQ "NXT
252 XEQ "NXT
253 "NUM COLS
254 XEQ "IN
255 XEQ "NXT
256 RCL 10
257 *
258 RCL 04
259 +
260 1
261 ST+ 00
262 RDN
263 STO IND 00
264 RCL 09
265 +
266 XEQ "SIZE?
267 FC?C 25
268 PROMPT
269 RTN
```




```
270 LBL "SIZE?
271 "SIZE>=
272 ARCL X
273 1
274 -
275 SF 25
276 RCL IND X
277 RTN
```




```
278 LBL "NXT
279 1
280 ST+ 00
281 +
282 STO IND 00
283 RTN
```


```
284 LBL "SETL
285 1E03
286 /
287 1
288 +
289 STO IND Y
290 RTN
```

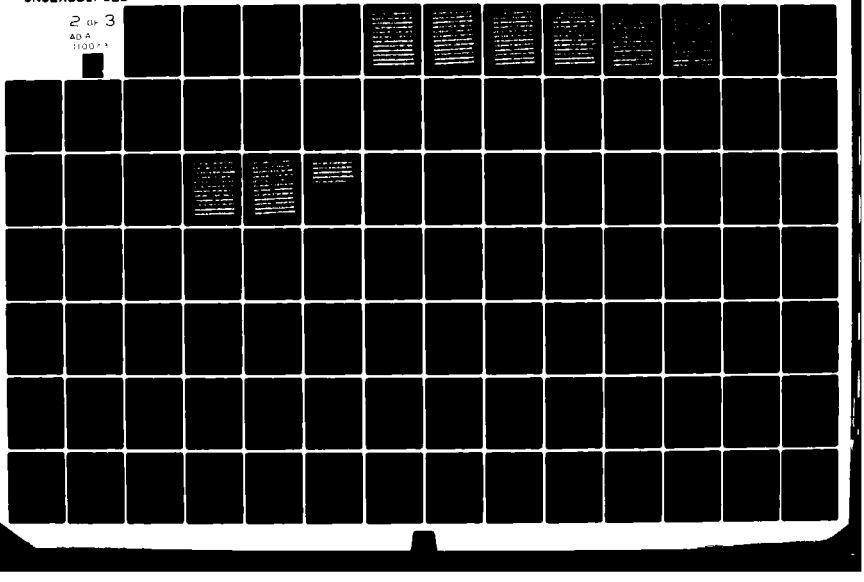
```
        ,(----------------------)
        |                      |
        |       READJB         |
        |                      |
        `----------------------'
291 LBL "READJB
292 1
293 RCL 08
294 XEQ "SETL
295 RCL 13
296 STO 00
297 FIX 0
298 LBL 01
299 "BASIC "
300 ARCL 01
301 "¬ "
302 XEQ "IN
303 ISG 01
304 GTO 01
305 FIX 4
306 RTN
```

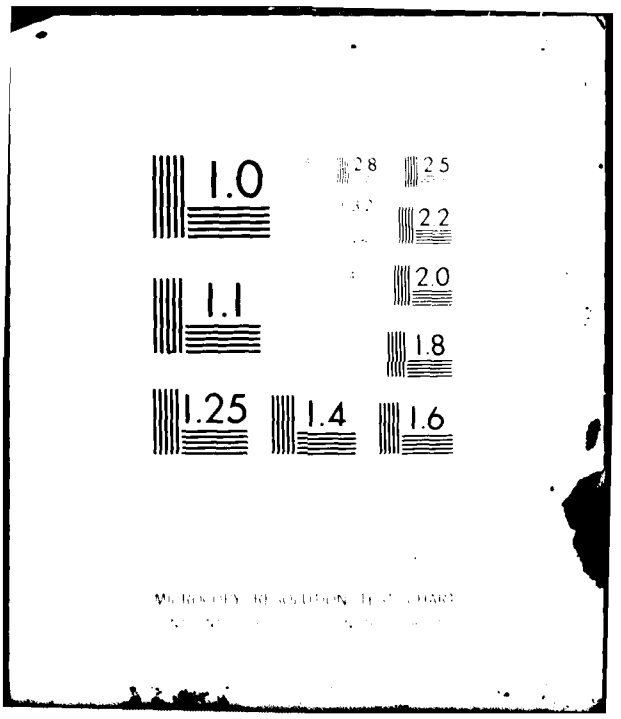
```
READA
```

```
LBL "READA
SF 10
1
RCL 09
XEQ "SETL
LBL 11
2
RCL 12
XEQ "SETL
LBL 12
FIX 0
"T
ARCL 01
"¬,
ARCL 02
FIX 4
LBL 13
RCL 01
1
-
RCL 12
*
RCL 02
+
RCL 04
+
1
-
STO 00
LBL 14
FC? 10
GTO 16
XEQ "IN
GTO 17
LBL 16
"¬=
ARCL IND 00
AVIEW
LBL 17
ISG 02
GTO 12
ISG 01
GTO 11
CF 10
0
RTN
```

AD-A110 073 NAVAL POSTGRADUATE SCHOOL MONTEREY CA F/G 9/2
A CROSS COMPILER AND PROGRAMMING SUPPORT SYSTEM FOR THE HP41CV --ETC(U)
SEP 81 J N RICHMANN

UNCLASSIFIED NL




1.0
2.8
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

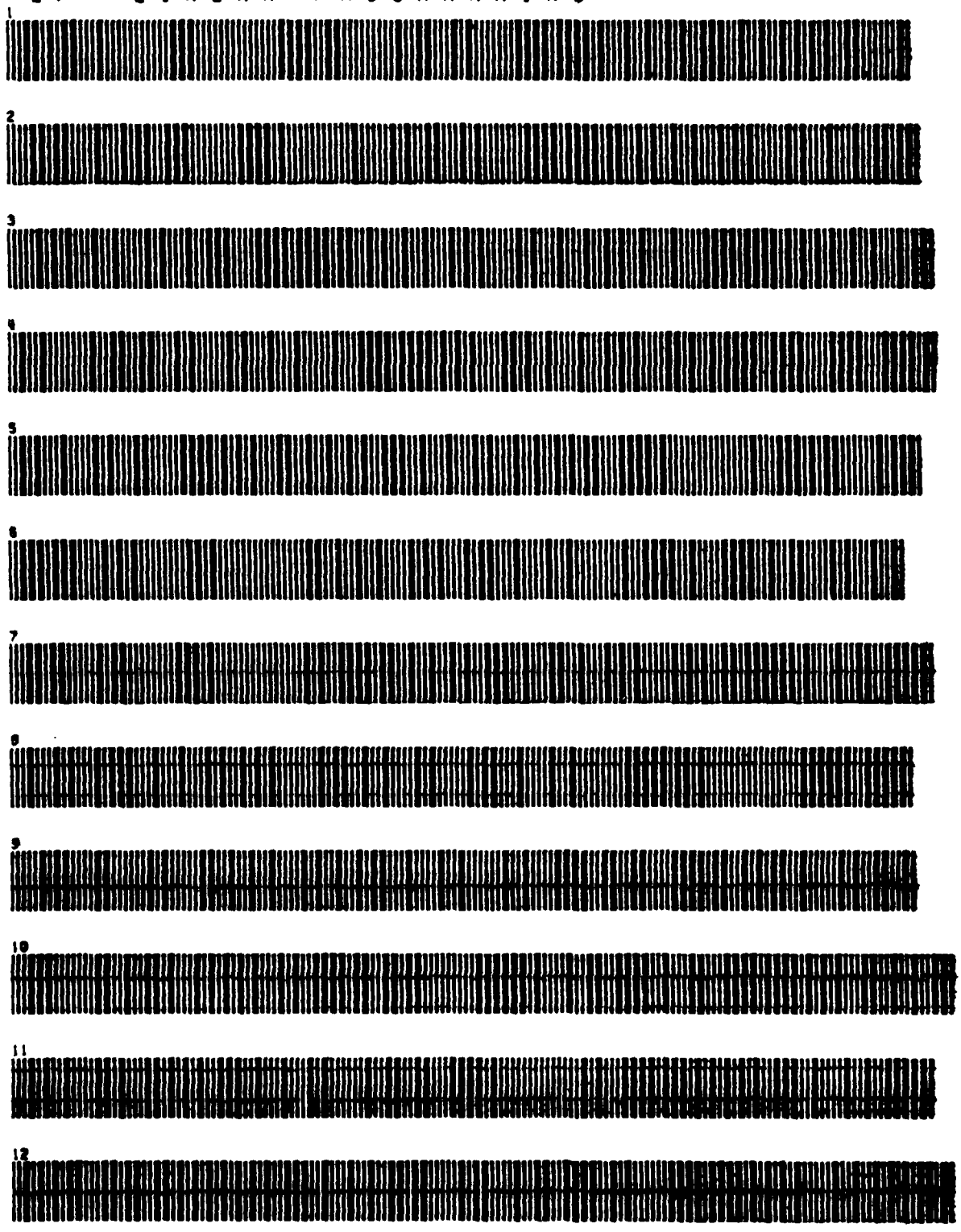
```
      ((----------------------)
      (                      )
      (          IN          )
      (                      )
      (----------------------)
353 LBL "IN
354 CF 22
355 1
356 ST+ 00
357 RCL IND 00
358 "¬?
359 PROMPT
360 STO IND 00
361 RTN
      (----------------------)
      (                      )
      (          INIT        )
      (                      )
      (----------------------)
362 LBL "INIT
363 CLRG
364 CF 29
365 1E-04
366 STO 07
367 19
368 STO 04
369 RTN
      (----------------------)
      (                      )
      (          ERR1        )
      (                      )
      (----------------------)
370 LBL "ERR1
371 0
372 LN
373 XEQ "READJB
```

```
        {(----------------------)}
        {                      }
        {        CHECK         }
        {                      }
        {----------------------}
374 LBL "CHECK
375 SF 11
376 1
377 RCL 12
378 XEQ "SETL
379 RCL 04
380 RCL 09
381 RCL 12
382 *
383 +
384 STO 14
385 STO 15
386 LBL 91
387 RCL 14
388 RCL 01
389 +
390 0
391 STO IND Y
392 ISG 01
393 GTO 91
394 1
395 RCL 08
396 XEQ "SETL
397 LBL 92
398 CF 07
399 RCL 13
400 RCL 01
401 +
402 RCL IND X
403 X<0?
404 SF 07
405 ABS
406 STO 00
407 X=0?
408 GTO "ERR1
409 RCL 12
410 X<=Y?
411 GTO "ERR1
412 2
413 RCL 09
414 XEQ "SETL
415 LBL 93
416 CF 08
417 RCL 01
418 INT
419 RCL 02
420 INT
421 X=Y?
422 SF 08
423 1
424 -
425 RCL 12
426 *
427 RCL 00
```

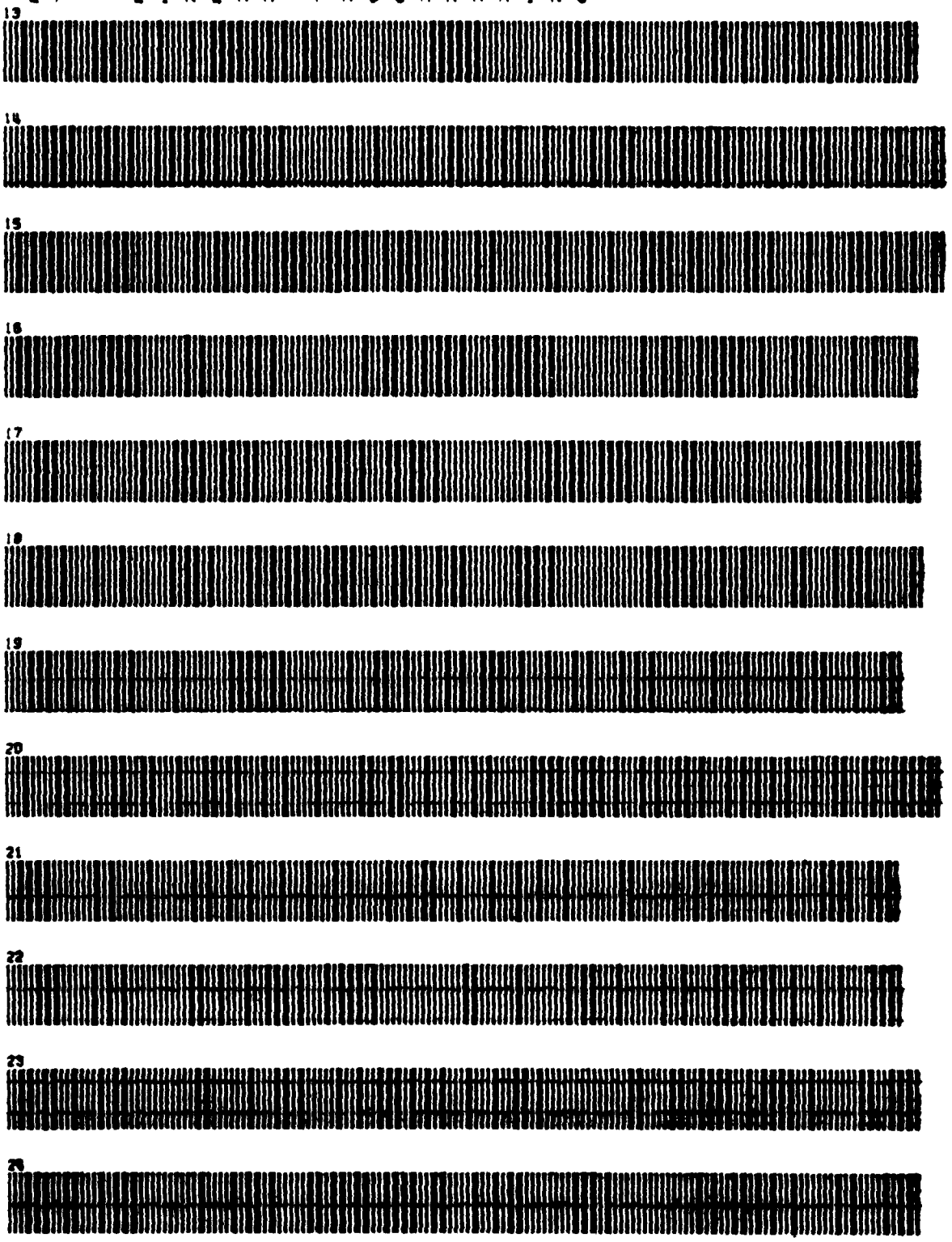
```
428 +
429 RCL 04
430 +
431 FC? 08
432 0
433 FS? 08
434 1
435 STO IND Y
436 ISG 02
437 GTO 93
438 FC? 07
439 GTO 98
440 CF 11
441 RCL 14
442 RCL 00
443 +
444 1
445 STO IND Y
446 2
447 RCL 12
448 XEQ "SETL
449 LBL 96
450 RCL 01
451 INT
452 1
453 -
454 RCL 12
455 *
456 RCL 02
457 +
458 RCL 04
459 +
460 RCL IND X
461 CHS
462 RCL 14
463 RCL 02
464 +
465 X<>Y
466 RCL IND Y
467 +
468 STO IND Y
469 ISG 02
470 GTO 96
471 LBL 98
472 ISG 01
473 GTO 92
474 FC? 11
475 RTN
476 RCL 04
477 RCL 08
478 RCL 12
479 *
480 +
481 STO 14
482 RTN
```

```
{(
    THE FOLLOWING TABLE DESCRIBES THE KEY REGISTER AND FLAG
    ASSIGNMENTS MADE BY THIS PROGRAM:

        R00 = TEMPORARY REGISTER.  HOLDS RECIPROCAL OF PIVOT
              ELEMENT IN SUBROUTINE PIVOT.
        R01 = LOOP INDEX COUNTER
        R02 = LOOP INDEX COUNTER
        R03 = TEMPORARY REGISTER.  HOLDS MIN VALUE IN FINDQ;
              MAX VALUE IN FINDP; AND IS AN INTERMEDIATE
              ADDRESS CALCULATION VALUE IN PIVOT.
        R04 = BASE REGISTER FOR INDIRECT ADDRESSING
              (SET = 19)
        R05 = THE PIVOT COLUMN NUMBER
        R06 = THE PIVOT ROW NUMBER
        R07 = EFFECTIVE ZERO LEVEL
        R08 = M = NUMBER OF ROWS
        R09 = M PLUS 1
        R10 = M PLUS 2
        R11 = N = NUMBER OF VARIABLES
        R12 = N PLUS 1
        R13 = BASE REGISTER FOR THE LOCATION OF THE
              VECTOR JB WHICH CONTAINS POINTERS TO
              WHICH VARIABLE IS BASIC IN EACH ROW.
        R14 = ROW NUMBER OF THE OBJECTIVE FUNCTION;
              SET TO M PLUS 1 OR M PLUS 2 AS DETERMINED
              BY NEED FOR PHASE I.
        R15 = BASE REGISTER FOR THE LOCATION OF THE
              PHASE I OBJECTIVE FUNCTION, IF NEEDED.
        R16 = TEMPORARY REGISTER.
        R17 = NUMBER OF PIVOTS PERFORMED.
        R18 = RESERVED FOR FUTURE USE.
        R19-R177 = DATA STORAGE REGISTERS FOR ELEMENTS OF
                   THE TABLEAU AND THE JB VECTOR.

                        FLAGS

    F01 - F03 = SUBROUTINE EXECUTION FLAGS.  BECAUSE THESE
                FLAGS ARE VISIBLE IN THE DISPLAY THEY CAN
                BE SET WHEN ENTERING A MAJOR SUBROUTINE AND
                CLEARED WHEN LEAVING -- GIVING THE USER A
                VISUAL INDICATION OF WHAT IS HAPPENING
                INSIDE THE CALCULATOR.

                F01--SUBROUTINE FINDQ
                F02--SUBROUTINE FINDP
                F03--SUBROUTINE PIVOT

    F04 = WHEN SET, STOPS CALCULATOR AFTER EACH PIVOT.
    F07 = USED AS TEMPORARY FLAG IN PIVOT AND CHECK ROUTINES.
    F10 = USED AS A TEMPORARY FLAG IN READ ROUTINES.
    F11 = WHEN SET, INDICATES PHASE II IS IN PROGRESS.
    F29 = CONTROLS FORMAT OF DISPLAY SEPARATOR.
483 END
```

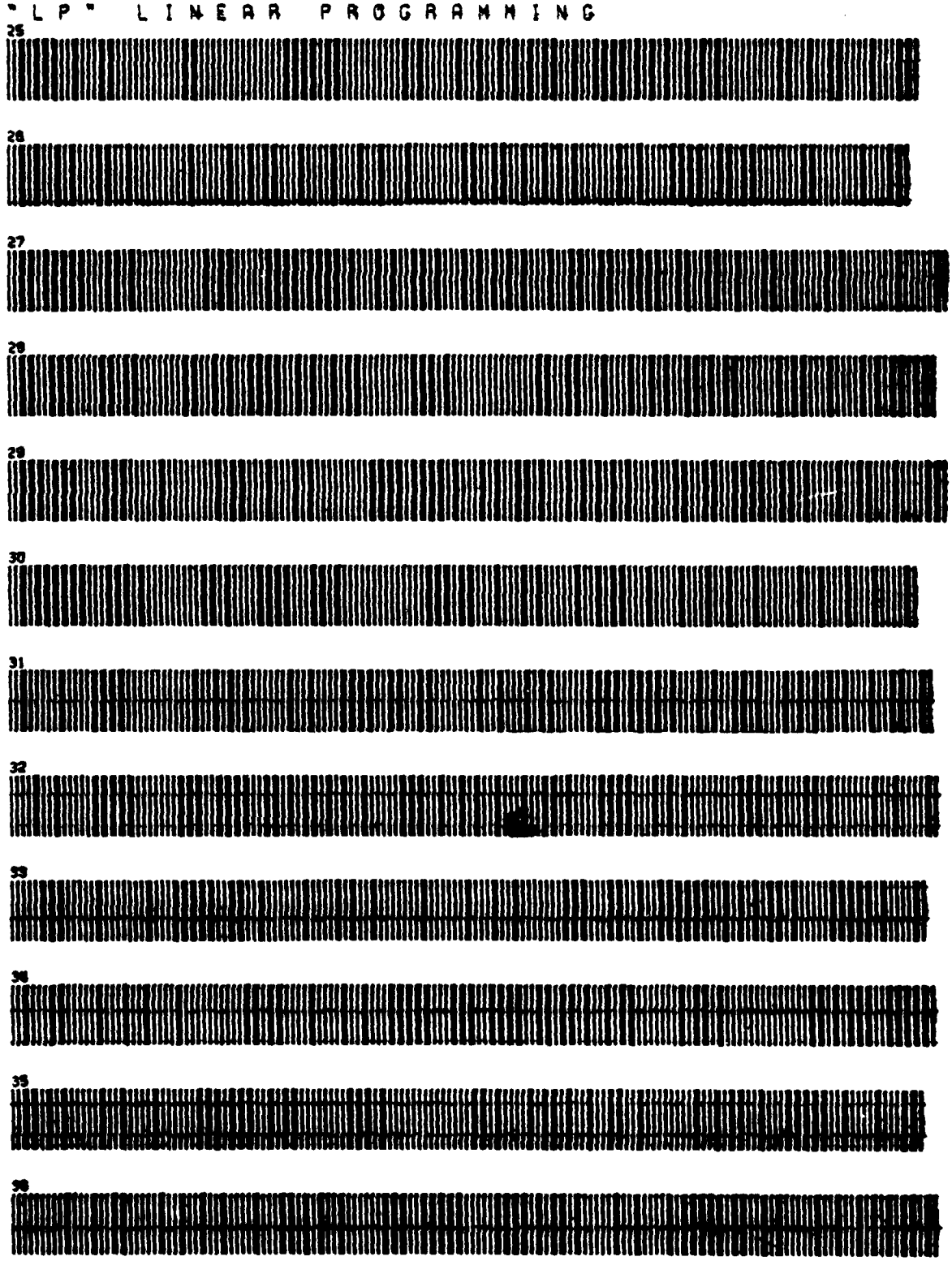
"LP" LINEAR PROGRAMMING



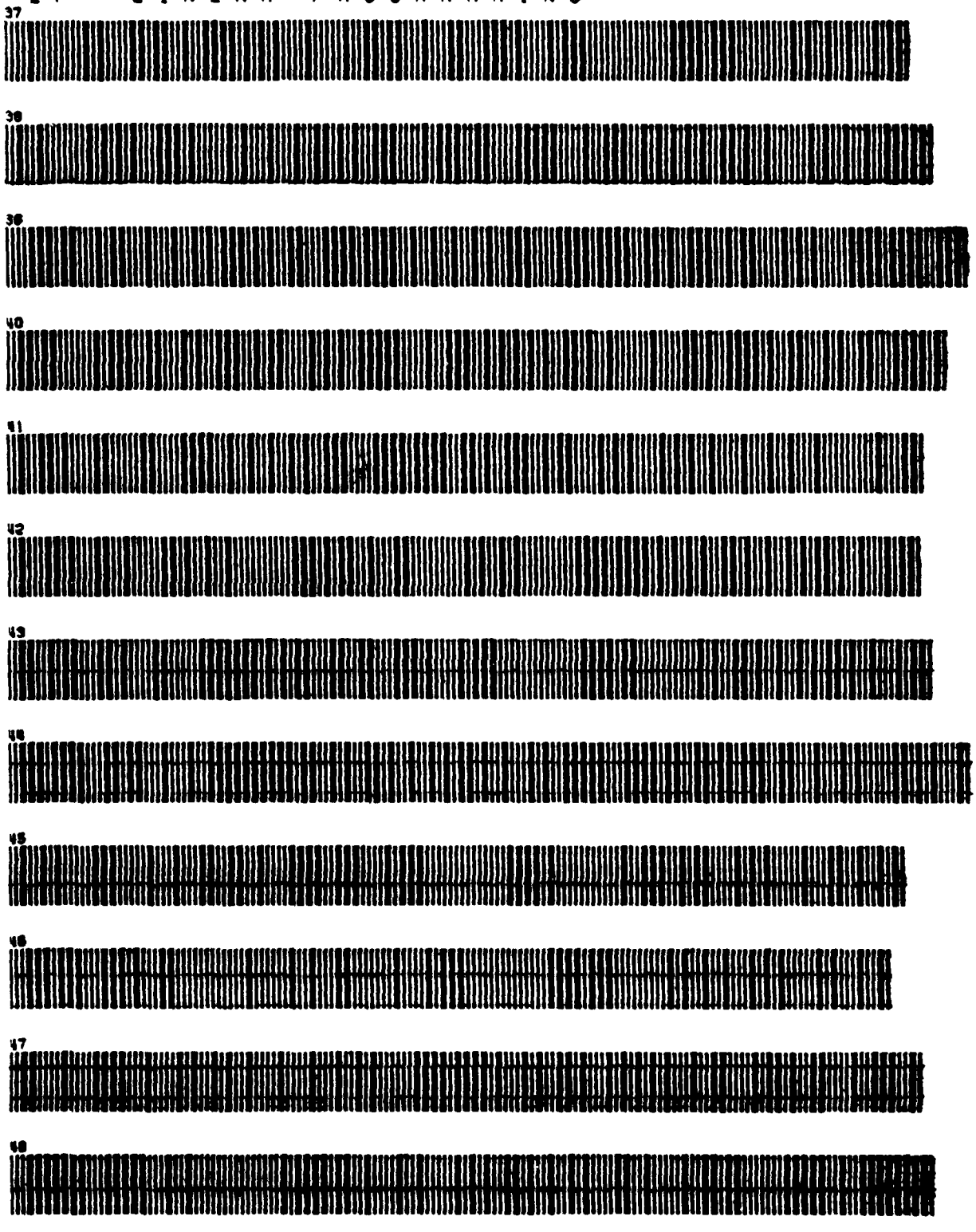
"LP" LINEAR PROGRAMMING



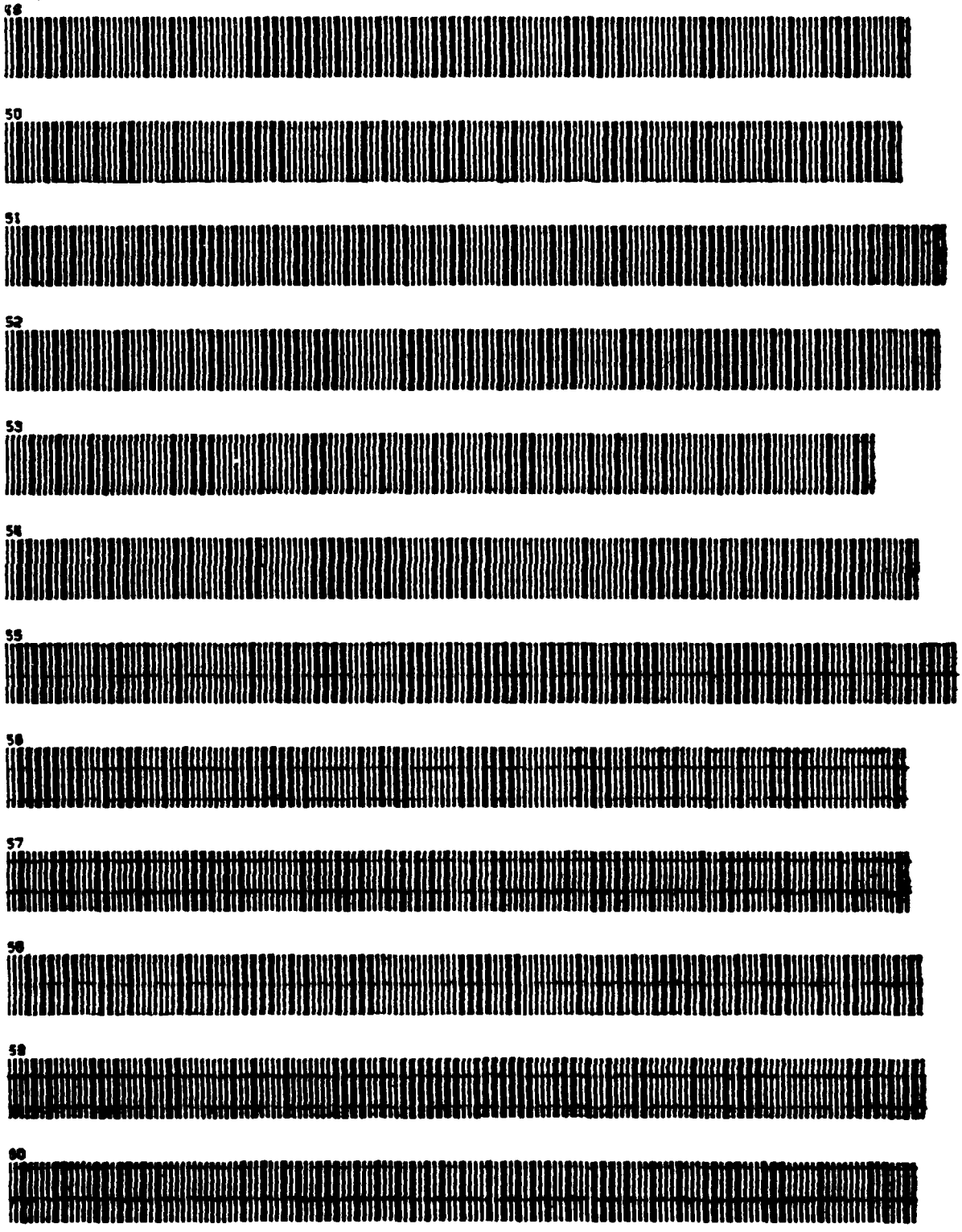
"LP" LINEAR PROGRAMMING



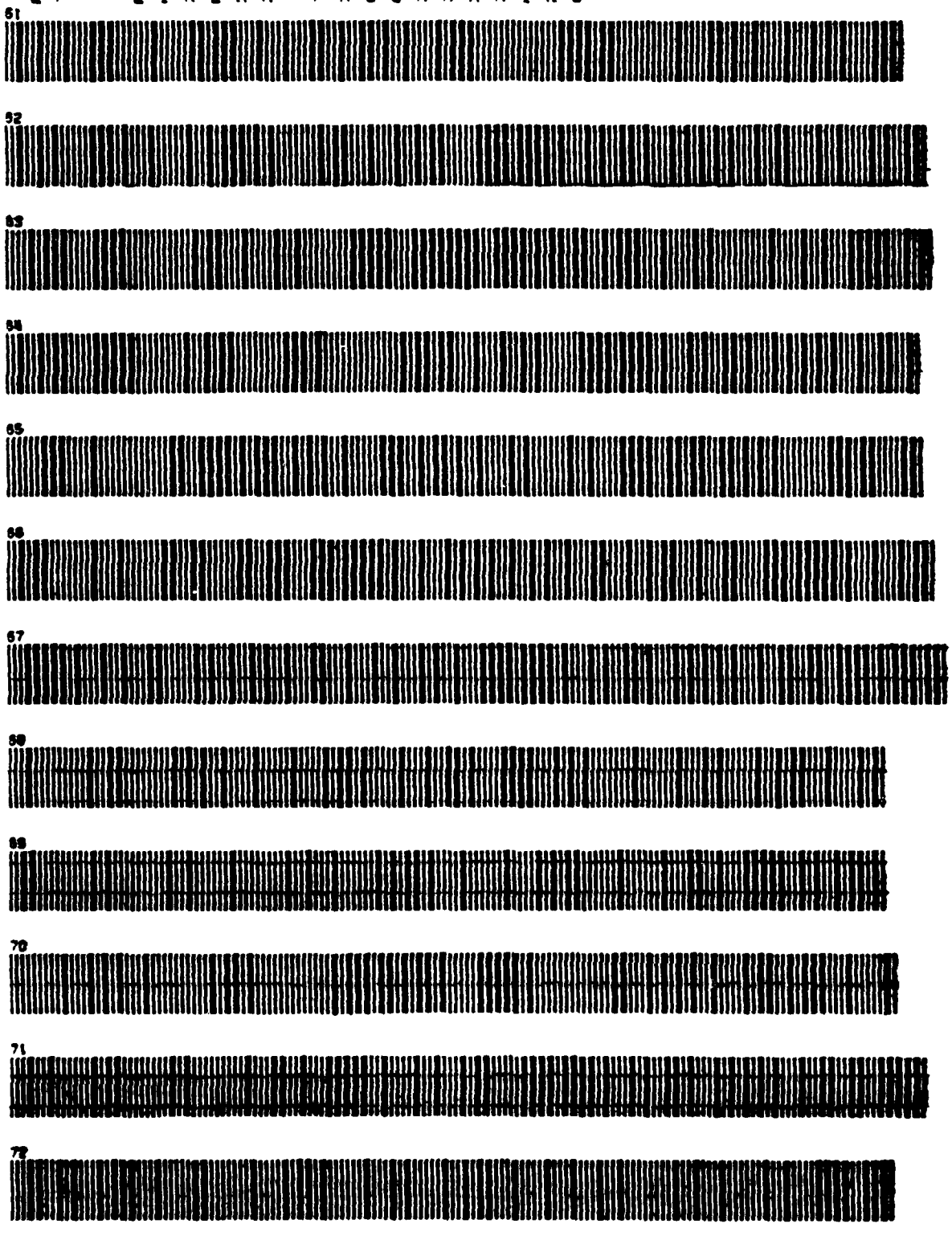
"LP" LINEAR PROGRAMMING



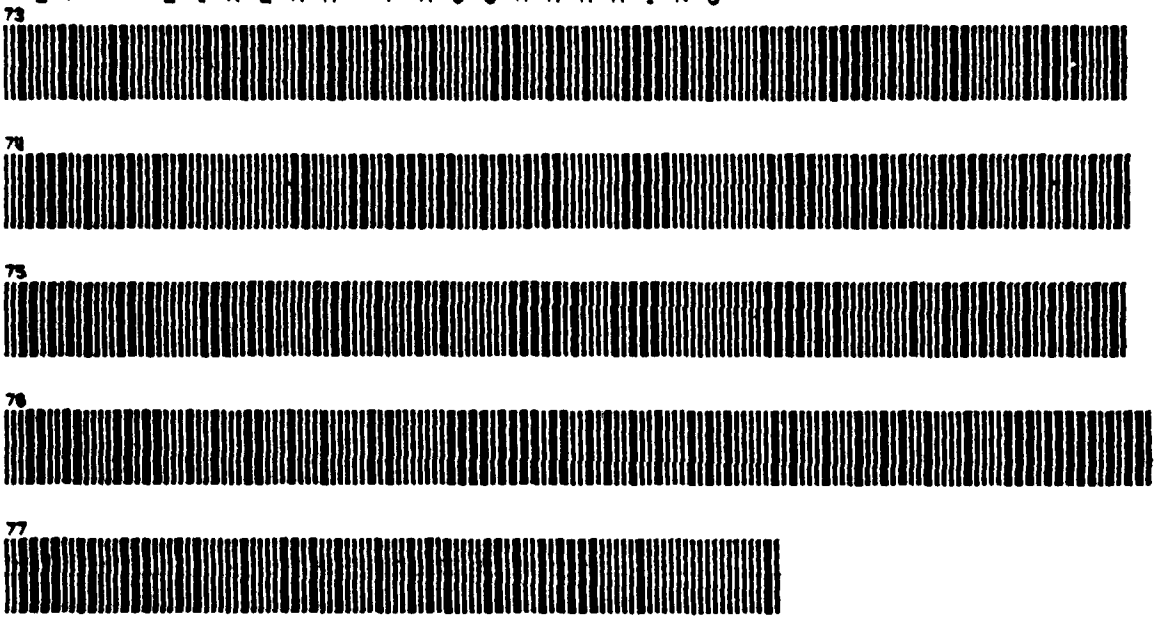
"LP" LINEAR PROGRAMMING



"LP" LINEAR PROGRAMMING



"LP" LINEAR PROGRAMMING



APPENDIX C

SUBROUTINES FOR READ ONLY MEMORY

INTRODUCTION:

The calculator subroutines described in this appendix perform functions which are frequently required by application programs and are therefore ideal candidates for use in a read only memory (ROM.) These routines were written especially to illustrate the differences between read only memory routines and routines designed for individual use via bar code or magnetic cards. These differences include more attention to entry and exit point options, an attempt to keep the size of the routines as compact as possible, and an attempt not to disturb the register stack if at all possible.

These common subroutines are provided separately from application programs because when more than one application program uses the routines, as is recommended for these programs, the use of a separate block of common functions saves space in the ROM overall. Also, by providing a convenient set of "macro" instructions, application programs can be constructed more quickly and easily. Because these

subroutines are used frequently, they have been individually optimized and tested to save memory space and execution time. By using these "macros" within an application program, the application programmer can be reasonably certain of their efficiency and reliability.

Almost all user/calculator interface is handled by these routines. There is one set of subroutines which assumes the user has a printer, and one set which does not. Printer instructions are preceeded in the listings shown in the appendix by an (PRT: label. When not using these routines on read only memory, the user will load one set or the other (but not both), as appropriate for his/her application. In so doing, the user with the printer gets full benefit from it while the user without the printer pays no penalty in execution time or memory space for the calculator's print instructions. Also, to change from use of the printer to use of the calculator without it, the user needs only to read in the new common block--the application programs are retained in memory unchanged. The subroutines appear the same to any application program--giving the added benefit that any application program which uses them for input or output operations will automatically make good use of

the printer even if written by a programmer who did not explicitly consider a printer requirement.

When using these common subroutines, a discipline is enforced upon the application program concerning use of the calculator memory registers. This saves the programmer from having to plan his "register map" from scratch for each new program. Also, it insures compatability across different application programs for similar data objects such as matrices and loop index counters. One of the most annoying problems with read only memory programs available from the calculator manufacturer is this lack of cross program compatability. Conflict in the use of memory registers is the rule, rather than the exception; and it is frequently impossible to efficiently use more than one read only memory program as a subroutine within a user written program. A third reason why register assignment standards are advantageous is that they make it easier for the user of the calculator to remember the key register assignments and, if necessary, recall their contents during the execution of an application program.

Another function performed by this set of common subroutines is to simplify the use of indirect addressing--a critical goal on the HP41CV.

Because the common subroutines listed in this appendix are always called by application programs and never from the keyboard by the user, the typical user instructions are inappropriate. Instead, for the benefit of application programmers wishing to use the routines, the basic functions and structure of each are explained in subsequent sections of this appendix.

Subroutine "IN"

Subroutine "IN" is used as a general input and output interface between the user and the calculator. This subroutine has three alternative entry points which when called affect functions as follows:

IN--Input mode (displays a question mark query)
IO--Output mode (displays labeled data value)
IX--Direct mode (input of value in x register)

In particular, one entry point, "IN", may be called whenever an application program must query the user for a numeric input value. As such, it is a direct replacement for the PROMPT instruction organic to the calculator, but automatically prompts, verifies and stores the received value using an indirect address contained in register 00. The printer version of the subroutine will automatically label and print the final, verified data value recorded.

Subroutine "IN" uses register 00 as a data location pointer and automatically increments this register so that subsequent calls to the subroutine will result in sequential data manipulation. The application programmer must insure that register 00 contains a number equal to the storage register number prior to calling the subroutine. For example, if register 00 contains 17, "IN" will store the data in register 17. One of the major advantages of this routine is that the same subroutine may be used to verify and/or change the data previously recorded. Thus, separate edit routines are usually unnecessary. Pressing the R/S key without touching any other key leaves the value stored unchanged. Pressing "1" and "+" and then "R/S" adds one to the current stored value, and so on for other function keys. Entering a new string of digits results in that new value being stored.

An additional feature of this subroutine is the "verify" mode indicated by flag 05. Flag 05 is reserved for this purpose and is set "on" by a call to subroutine "VR"--another of the subroutines in this common set. The verify mode is intended for use by a novice or other user who wishes to verify every data value as it is keyed into the calculator. The advantage is increased accuracy and confidence in the result.

Subroutine "D2"

Subroutine "D2" is used to set up the index register for a program loop. This subroutine has two alternative entry points which when called, increment different index registers as follows:

D2--Establishes register 02 as the index
D1--Establishes register 01 as the index

This subroutine is intended for use with the "ISG" loop structure which has the effect most like that of a FORTRAN "DO LOOP." For example, to execute a loop 20 times:

```
...
...
20
XEQ "D1
LBL 00
    ....
    ....
ISG 01
GTO 00
...
...
```

The advantage of this form of loop structure is that register 00 may be used within the loop for address calculations. The first time the loop is addressed the integer portion of the number in register 00 will be 1, the second time it will be 2 and so on. There is no need to truncate the fractional portion of the number because the HP41C ignores the fractional component of a number when calculating a register address. Use of index registers for address calculation makes indirect addressing practical.

Registers 01 and 02 should be reserved for use as index registers by the application programmer. In most cases these two registers should prove sufficient.

Subroutine "VR"

Subroutine "VR" is used as a general purpose calculator initialization routine. This subroutine has three alternative entry points which vary the amount of initialization performed as follows:

VR--Sets the verify mode on, and the following:
WR--Suppresses the audio tones, and the following:
WS--Clears all memory,
Sets the display for integers,
Assigns statistical regisers,
Sets "zero" level for equality testing, and
Sets base address for indirect addressing.

In the printer version of this initialization routine, the subroutine prints a banner (usually the program name) which has been stored in the alpha register prior to calling the initialization subroutine.

If flag 13 is set prior to calling the initialization routine, then the calling program must have placed the number of data registers required to execute the program in the x register prior to calling the initialization routine. In this case, a check will automatically be performed using subroutine "SZ" described below.

It is recommended that all application programs provide an alternate entry point which bypasses the initialization

step. Then if a data error is encountered, the user may review the data entered into the calculator by simply pressing the return key once after every prompt. This procedure works because subroutine "IN" recalls the stored value prior to prompting the user. When the user presses the clear key, the alphabetic prompt is removed and the existing data value revealed.

Subroutine "SZ"

Subroutine "SZ" is used to test if sufficient numbers of data registers are available to run an application program. This subroutine may be either called directly or as part of the initialization routine described above.

Subroutine "ER"

Subroutine "ER" is called whenever the application program encounters an error--usually in the input data. A prompt is displayed and an audio tone sounded, provided flag 26 (the audio enable flag) has not been cleared by the initialization routine described in paragraph D.

Subroutine "SORT"

This subroutine is included to illustrate the use of a stack register table in the program comments, but it also represents a useful utility routine. The sorting algorithm

used is the shell sort [Ref. 6: pp. 84-95] which gives reasonably fast sorting times with a very small program size. All conventions such as base register in R04 and number of data points in R15 are assumed by this subroutine. A complete list of all such register assignments is listed at the end of the program listing.

Subroutines "PUT" and "GET"

These two small routines provide a useful capability to store and recall up to three integers between 0 and 999 in one data register. This means that if you are manipulating a spread sheet of small, positive integers you can store the same data in one third the space. Of course, run time is degraded (about 20 seconds for every 100 data references.) To store a value, assuming the base register has been defined, just press:

value ENTER↑ point-number XEQ "PUT

To recall a value, simply press:

point-number XEQ "GET

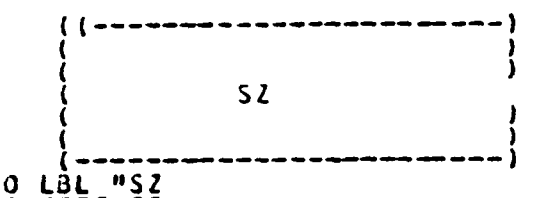
```
      ((----------------------)
      (                      )
      (                      )
      (          IN          )
      (                      )
      (                      )
      (----------------------)
 1 LBL "IN              (INPUT MODE--DISPLAY LABEL AND ?
 2 SF 10                (SET QUERY ONCE FLAG
 3 GTO 05
 4 LBL "IC              (OUTPUT MODE--DISPLAY LABEL AND DATA
 5 CF 10                (INSURE NO QUERY
 6 LBL 05
 7 RCL IND 00           (ASSUMES R00 POINTS TO STORAGE REG
 8 LBL "IX              (DIRECT MODE--ASSUMES X REG HOLDS DATA
 9 ASTO 05              (ASSUMES LABEL SET UP BY CALLING PROG
10 LBL 01
11 "¬="
12 FS? 10               (QUERY OR DISPLAY VALUE?
13 "¬?"
14 FC? 10
15 ARCL IND 00          (DISPLAY DATA VALUE
16 CF 22                (DIGIT ENTRY DETECTION FLAG
    (PRT: FS? 10
    (PRT: CF 21            (DISABLE PRINTER FOR QUERY
17 PROMPT
    (PRT: SF 21
18 STO IND 00           (STORE INPUT VALUE
19 CLA                  (PREPARE ALPHA REG FOR NEXT PROMPT
20 FC? 05               (NOT VERIFY MODE?
21 GTO 03
    (FOLLOWING IS ACTION TAKEN WHEN IN VERIFY MODE
22 FS? 22               (ANY INPUT DETECTED?
23 GTO 02               (REDISPLAY VALUE IF USER INPUT
24 FC? 10               (DISPLAY VALUE ONCE IF NO INPUT
25 GTO 04
26 LBL 02               (DISPLAY LABEL AND DATA VALUE
27 CF 10                (NOTE MUST HAVE QUERIED ONCE
28 ARCL 05
29 GTO 01
    (FOLLOWING IS ACTION TAKEN FOR NON-VERIFY MODE
30 LBL 03
31 FS?C 10              (INPUT MODE?
32 GTO 04               (IF INPUT MODE, EXIT ROUTINE
33 FS? 22               (WAS THERE INPUT ?
34 GTO 02               (USER CHANGED VALUE, SO VERIFY.
35 LBL 04               (PREPARE TO EXIT
    (PRT: FS? 55           (PRINTER ATTACHED?
    (PRT: GTO 06
    (PRT: LBL 05
36 ISG 00               (INCREMENT POINTER FOR NEXT IO OPERATION
37 RTN
38 RTN                  (FINAL VALUE IS IN X REG UPON EXIT
    (PRT: LBL 06           (PRINT THE FINAL VALUE
    (PRT: CLA
    (PRT: ARCL 05
    (PRT: "¬="
    (PRT: ARCL IND 00
    (PRT: PRA
    (PRT: GTO 05
```

HP41C SOURCE CODE: COMMON SUBROUTINES

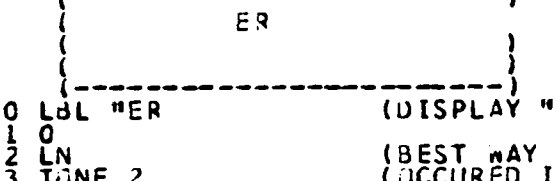
```
      ((----------------------)
      (                      )
      (                      )
      (          D2          )
      (                      )
      (                      )
      (----------------------)
39 LBL "D2              (SETUP LOOP USING REG 2 AS INDEX COUNTER
40 2
41 GTO 07
42 LBL "D1              (SETUP LOOP USING REG 1 AS INDEX COUNTER
43 1
44 LBL 07
45 X<>Y                 (NUMBER LOOP ITERATIONS MUST BE IN X
46 1E3                  (PRIOR TO CALLING THIS SUBROUTINE.
47 /
48 1
49 +
50 STO IND Y
51 RTN
```

```
     {{----------------------}
     {                      }
     {                      }
     {          VR          }
     {                      }
     {                      }
     {----------------------}
52 LBL "VR              (SET VERIFY MODE ON
53 SF C5
54 LBL "WR              (INITIALIZE FOR CLASSROOM USE -- NO AUDIO
55 CF 26
56 LBL "WS              (STANDARD INITIALIZATION ROUTINE FOLLOWS
57 CLRG
58 &REG 10
59 CF 29                (SETS DISPLAY--NO DECIMAL POINT IF INTEGER
60 1E-C4                (EFFECTIVE ZERO LEVEL
61 STO 03
62 15                   (NORMAL INDIRECT ADDRESS BASE REGISTER.
63 STO 04               (THIS IS 1 LESS THAN THE NUMBER OF THE
64 1
65 +
66 STO 00               (FIRST REGISTER WHERE DATA IS STORED.
    (PRT: ADV
    (PRT: SF 12            (DOUBLE WIDE PRINTING
    (PRT: FC? 55           (PRINTER ATTACHED?
    (PRT: PRA
    (PRT: CF 12            (SET BACK TO SINGLE WIDE PRINT
    (PRT: ADV
67 FC? 13               (HAS INITIALIZATION ROUTINE BEEN ASKED TO
68 RTN                  (VERIFY SIZE?
69 X<> Z
```

HP41C SOURCE CODE: COMMON SUBROUTINES




```
70 LBL "SZ
71 "SET SZ=
72 ARCL X
73 1
74 -
75 SF 25                  (PREPARE TO IGNORE ERROR
76 RCL IND X              (TEST FLAG 25 TO SEE IF SUFFICIENT
77 FC?C 25
78 PROMPT
79 RTN                    (SIZE EXISTS.
```




```
80 LBL "ER                (DISPLAY "DATA ERROR" PROMPT & SOUND TONE.
81 0
82 LN                     (BEST WAY TO DETERMINE WHERE ERROR
83 TONE 2                 (OCCURED IS TO HIT THE SST KEY ONCE,
84 RTN                    (THEN GO INTO PRGM MODE.
```

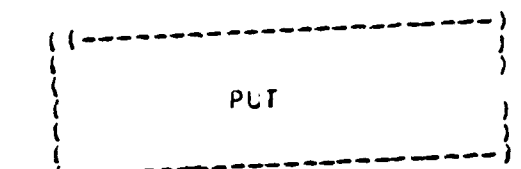
HP41C SOURCE CODE: COMMON SUBROUTINES

```
      {{----------------------}
      {                      }
      {                      }
      {         SORT         }
      {                      }
      {                      }
      {----------------------}
 85 LBL "SORT
 86 RCL 15                    (RECALL NUMBER OF DATA POINTS
 87 STO 01                    (DEFINE A = "MIDPOINT" OF NUMBER POINTS
 88 LBL 00
 89 RCL 01                    (RECALL MIDPOINT
 90 2
 91 /
 92 INT
 93 STO 01                    (A = INT(A/2)
 94 X=0?                      (TEST TO SEE IF LIST SORTED
 95 RTN
 96 1
 97 STO 02                    (B = 1  -- RESET LEFT SHELL BOUNDARY
 98 LBL 01                {   STACK TABLE FOLLOWS:
 99 STO 03                {   C=B          B
100 LBL 02                {   C            B
101 RCL 01                {   A            C          B
102 +                     {   D=C+A        B
103 RCL 04                {   BASE         D          B
104 +                     {   ADDR D       B
105 RCL IND X             {   X(D)         ADDR D     B
106 RCL 03                {   C            X(D)       ADDR D     B
107 RCL 04                {   BASE         C          X(D)       ADDR D
108 +                     {   ADDR C       X(D)       ADDR D
109 X<>Y                  {   X(D)         ADDR C     ADDR D
110 RCL IND Y             {   X(C)         X(D)       ADDR C     ADDR D
111 X<=Y?
112 GTO 03                (FOLLOWING WILL INTERCHANGE X(C) AND X(D)
113 STO IND T             {   X(C)         X(D)       ADDR C     ADDR D
114 X<>Y                  {   X(D)         X(C)       ADDR C     ADDR D
115 STO IND Z             {   X(D)         X(C)       ADDR C     ADDR D
116 RCL 03                {   C
117 RCL 01                {   A            C
118 -                     {   C=C-A
119 STO 03                {   C
120 X>0?
121 GTO 02
122 LBL 03
123 RCL 15                {   N
124 RCL 01                {   A            N
125 -                     {   E=N-A
126 RCL 02                {   B            E
127 1                     {   1            B          E
128 +                     {   B+1          E
129 STO 02                {   B=B+1        E
130 X<=Y?
131 GTO 01
132 GTO 00
      {
      {              SORT    USES THE FOLLOWING REGISTERS:
      {                      R01 -- A
      {                      R02 -- B
      {                      R03 -- C
      {                      R04 -- INDIRECT ADDRESS BASE
      {                      R15 -- NUMBER DATA POINTS (SET BY &+)
```

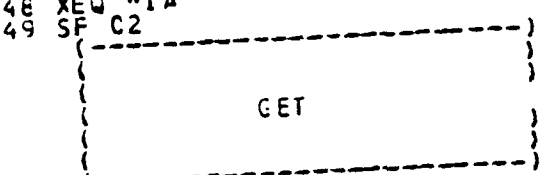
```
((----------------------)
(                      )
(                      )
(          SC          )
(                      )
(                      )
(----------------------)
```

```
133 LBL "SC
134 RCL 00
135 1
136 +
137 STO 05
138 -1EC3
139 STO 10
140 -1
141 3
142 /
143 STO 09
```

HP41C SOURCE CODE: COMMON SUBROUTINES




```
144 LBL "PUT
145 "VALUE
146 11
147 STC 00
148 XEQ "IA
149 SF 02
```

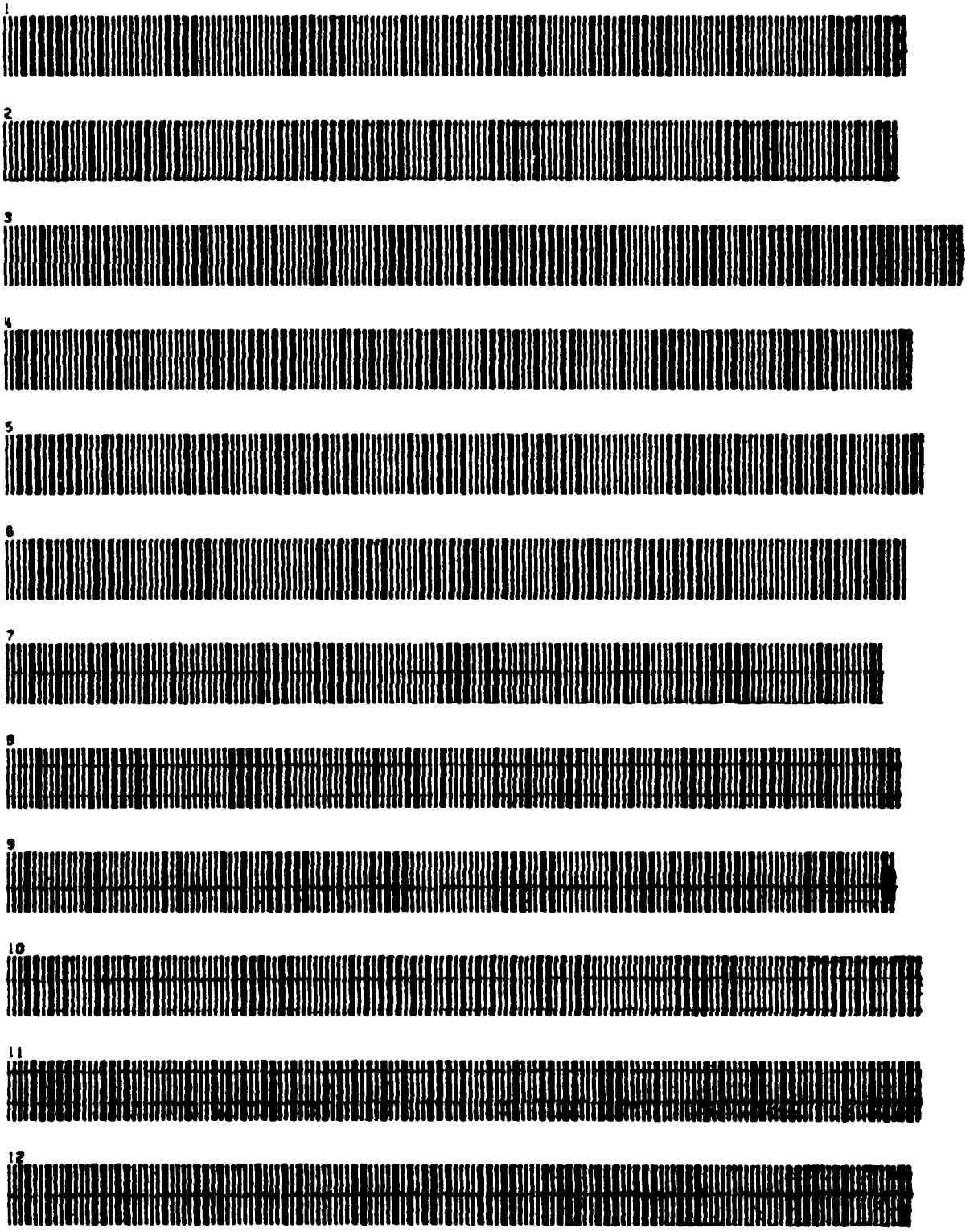



```
150 LBL "GET
151 "BIT REG
152 PROMPT
```

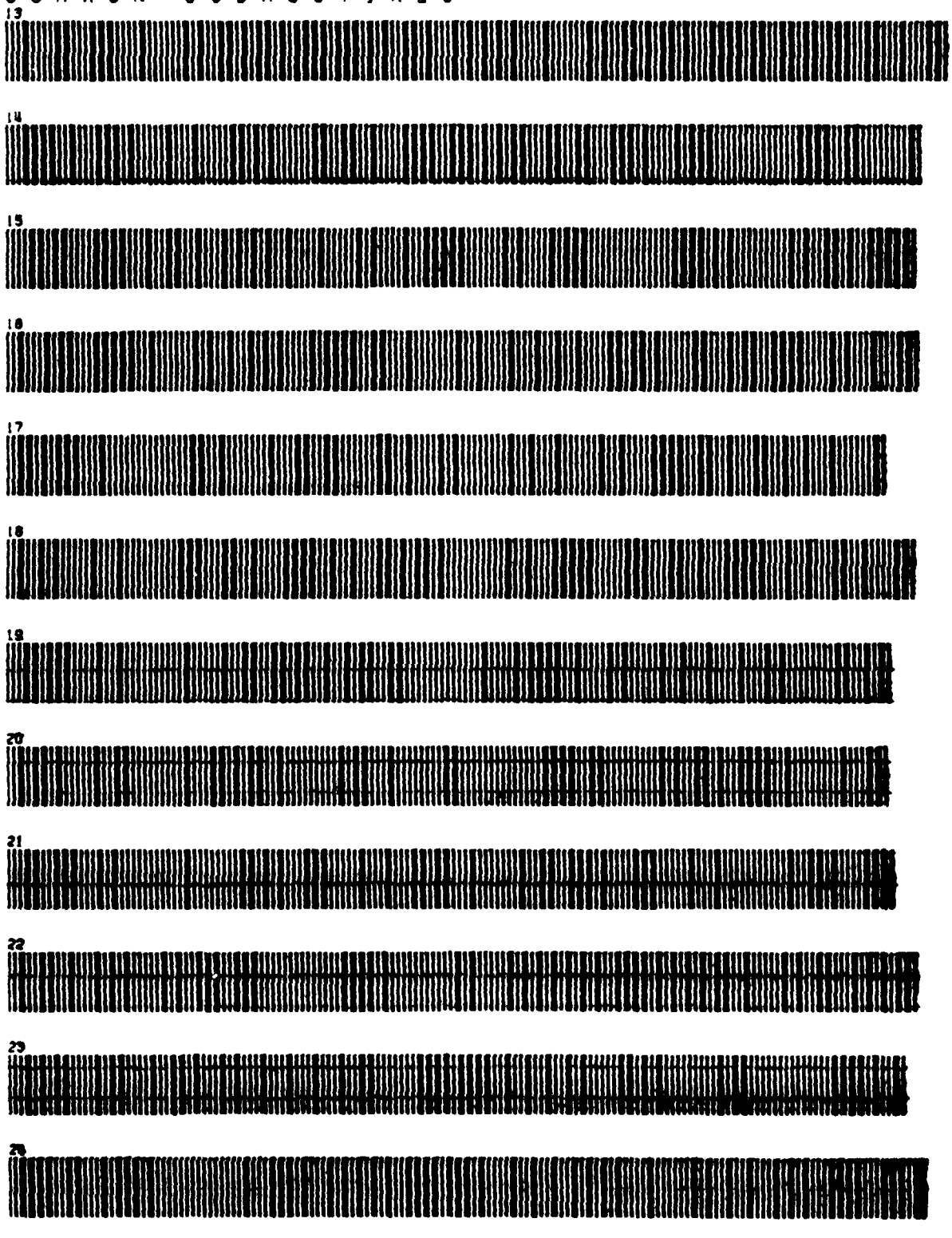
```
        ((----------------------)
        (                      )
        (                      )
        (          SA          )
        (                      )
        (                      )
        (----------------------)
153 LBL "SA
154 3
155 /
156 INT
157 STO 07
158 LASTX
159 -
160 RCL 09
161 /
162 12
163 +
164 STO 03
165 RCL 05
166 ST+ 07
167 RCL IND 07
168 INT
169 STO 14
170 LASTX
171 -
172 RCL 10
173 *
174 INT
175 STO 13
176 LASTX
177 -
178 RCL 10
179 *
180 INT
181 STO 12
182 RCL 11
183 RCL IND 08
184 STO 11
185 FC?C 02
186 RTN
187 X<>Y
188 STO IND 08
189 RCL 12
190 RCL 10
191 CHS
192 /
193 RCL 13
194 +
195 RCL 10
196 CHS
197 /
198 RCL 14
199 +
200 STO IND 07
201 RTN
```

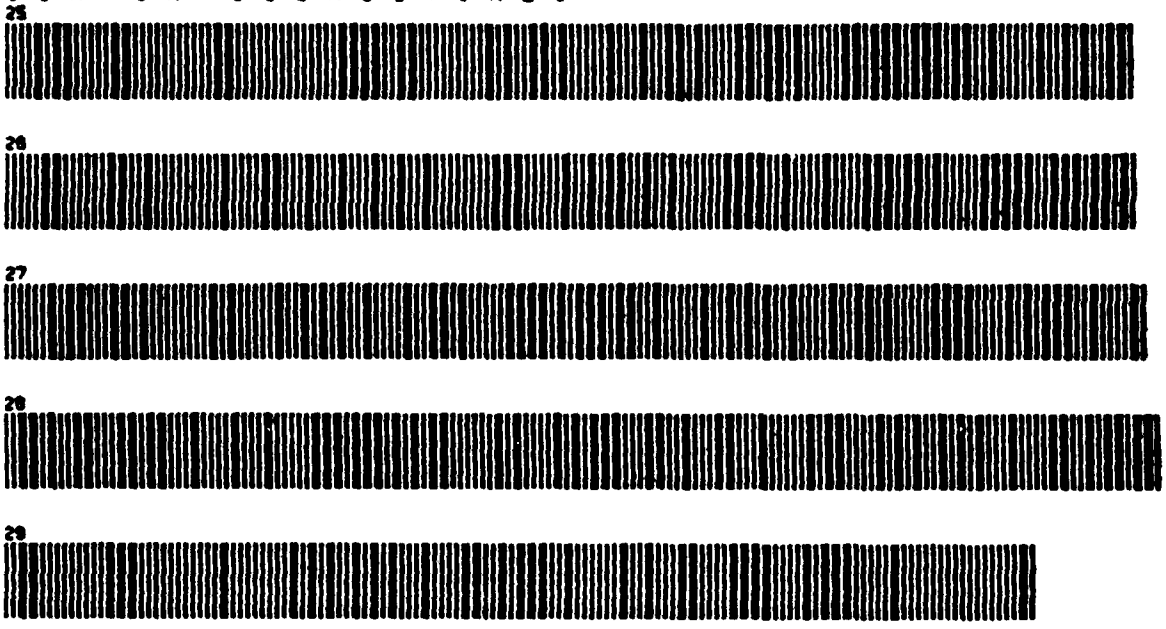
```
        {{
        {
        {
        {  THE FOLLOWING TABLE DESCRIBES THE KEY REGISTER AND FLAG
        {  ASSIGNMENTS MADE BY THIS PROGRAM:
        {
        {       R00 = INDIRECT ADDRESS FOR STORAGE OF INPUT DATA
        {       R01 = LOOP INDEX COUNTER
        {       R02 = LOOP INDEX COUNTER
        {       R03 = EFFECTIVE ZERO LEVEL -- USE AS TEMP IF NA
        {       R04 = BASE REGISTER FOR INDIRECT ADDRESSING (15)
        {       R05 = TEMP REGISTER FOR ALPHA PROMPT
        {       R06 - R09 = APPLICATION PROGRAM TEMP REGISTERS
        {       R10 - R15 = STATISTICAL REGISTERS--USE AS TEMP IF NA
        {       R16....   = STORAGE OF DATA VIA INDIRECT ADDRESSING
        {
        {                         FLAGS
        {
        {       F00-F0+ = SUBROUTINE EXECUTION FLAGS.  BECAUSE THESE
        {                 FLAGS ARE VISIBLE IN THE DISPLAY THEY CAN
        {                 BE SET WHEN ENTERING A MAJOR SUBROUTINE AND
        {                 CLEARED WHEN LEAVING -- GIVING THE USER A
        {                 VISUAL INDICATION OF WHAT IS HAPPENING
        {                 INSIDE THE CALCULATOR.  USE AS TEMPORARY
        {                 FLAGS IF THIS IS NOT REQUIRED.
        {
        {       F05   = VERIFY INPUT MODE.  "ON" WHEN SET.  WHEN SET
        {                 AFTER EVERY DATA VALUE IS ENTERED, THE CALC.
        {                    WILL ECHO THE PROMPT AND DATA VALUE ENTERED.
        {                    IF VALUE IS CORRECT, SIMPLY PRESS R/S KEY,
        {                    OTHERWISE  ENTER A CORRECTED VALUE AND
        {                    CALCULATOR WILL AGAIN ASK FOR VERIFICATION.
        {
        {       F10 = USED AS A TEMPORARY FLAG INSIDE "IC".  INDICATES
        {             NO QUERY PROMPT IS DESIRED.
        {       F11 = AUTOMATIC EXECUTION FLAG -- DON'T USE EVER
        {       F12 = DOUBLE WIDE PRINTING -- LOCAL WITHIN "IO".
        {       F13 = WHEN SET MEANS MAIN ROUTINE ASKING "VR" FOR
        {             AUTOMATIC SIZE CHECK AFTER INITIALIZATION.
        {             APPLICATION PROGRAM MAY USE FREELY AFTER INIT.
        {       F14 - F20 = AVAILABLE FOR APPLICATION PROGRAM USE.
202 END
```

COMMON SUBROUTINES



COMMON SUBROUTINES





APPENDIX D

THE CROSS COMPILER PROGRAM AND COMMAND PROCESSOR

DESIGN METHODOLOGY:

This appendix discusses the design methodology used during construction of both the cross compiler program and the command processor, which is an IBM EXEC II program which provides an interactive programming environment for users of the system.

Blazie's compiler for the HP65 calculator [Ref. 9] represents one of the first attempts to provide a compiler for calculator programs. Both Carvalho [Ref. 10: pp. 25-29] and McNeal [Ref. 11: pp. 148-178] have published BASIC language programs which cross compile HP41CV instructions on a microcomputer for output to a line printer which can print acceptable bar code. While these referenced programs provided valuable insights into the problem, especially into the special characteristics of the HP41CV instruction set, none was exactly suited to the needs of this study. Because the Versatec plotter at the Naval Postgraduate School could be easily used only by FORTRAN programs, FORTRAN seemed the computer language of choice for this project. Both programs

were written with limited objectives and neither would have easily supported the extensions desired. Extensions planned for implementation included:

- An extended instruction set.
- In code comments.
- Extensive error checking.
- Compatability with the Emulator.
- Synthetic Instructions [Ref. 1].
- Instruction macro's.

Having decided to code an original cross compiler, a design methodology which would capitalize on the advantages of FORTRAN was planned. FORTRAN's major deficiency for use in constructing a compiler of any type is its lack of alpha-numeric string handling capabilities. Rather than struggle with the lack of string functions, it was decided to code the necessary string functions as separate subroutines. This decision was reinforced countless times throughout the process of writing the compiler. The string function subroutines have been used not only in the cross compiler, but in many other FORTRAN programs since they were originally written. In fact, many persons who have no

interest in the HP41CV cross compiler may find the set of string functions listed in this thesis to be a valuable set of utility routines to be used to augment FORTRAN. The general convention used througout the string function subroutines is that an alphabetic string may be represented as a vector of two byte integer variables used to store the characters and a single four byte integer variable used to store the length of the string.

One of the major advantages of the cross compiler is its ability to handle comments integrated within the HP41CV source code. This feature is critical to the clarification of the logical structure of the HP41CV programs. Because the parenthesis is not a valid HP41CV character, it was chosen as the comment indicator character. A comment may occur beginning at the first column on an input line or anywhere after an HP41CV instruction. The comment must follow the instruction because everything after the comment mark out to the end of the input line is considered part of the comment.

The control the user has over the output listing is also one of the advantages of the cross compiler. When two comment indicator marks are placed in positions one and two of the input line, the compiler will force a page eject when printing the output listing. In addition, the user can vary

the number of output lines per page and cause useful banners to be placed adjacent to program labels for ease of recognition.

Altogether there are twenty-four subroutines and a main program which constitute the cross compiler. The source code for each of these routines is provided in the second section of this appendix. Each subroutine begins with a statement concerning its function and construction. Accordingly, no general description of each subroutine will be repeated here. However, subroutine COMP deserves special attention, for it is the master lexicographic analyzer for the compiler and would also interface the user with the emulator. Its function is to receive a single line of HP41CV source code and identify it. COMP considers all HP41CV instructions to be of one of three types. The first category are the single byte instructions with no operands that can be compiled by a simple table look up. COMP has been constructed so that the instruction set can be extended at any time simply by increasing the size of this table. In this way abbreviated or altered command names could be easily used. The second category of instructions are the multi-byte instructions which require a table lookup and the translation of one or more operands, including possibly an

indirect instruction indicator. The table examined by the compiler is the same as for the category one instructions, and a code is given in the table which indicates to the compiler the number of operands which are required with each instruction. A syntax check is then made in subroutines IONE and ITWO to insure that the number and characteristics of each operand are appropriate for the given instruction. One of the major advantages of the use of the cross compiler is the syntax and error checking that is performed during the compilation process. The third type of instruction represents the exceptional instructions that are so difficult to compile that they require separate subroutines for efficient compilation. These instructions include storage and recall of data, program labels and program flow control statements such as goto and execute.

In order to provide an efficient programming command system for the compiler that would minimize the need to know technical details about the operation of the compiler, an IBM EXEC II program was written. This program not only interfaces the user to the compiler, but it also provides on line user instructions as to how to use the system. Included in this command processor is a command menu which gives the format and short description for each command.

Another command, help, provides more detailed information about each command. When a novice user first enters the exec, or types the name of the exec followed by a question mark, then he receives a four page narative description of what the system is, how it works, and what actions he must take to write a successful HP41CV application program.

```
&TRACE
*****************************************************************
***                                                           **
***      HP41CV CROSS COMPILER COMMAND PROCESSOR              **
***                                                           **
***      THIS IBM EXEC II PROGRAM PROVIDES AN INTERACTIVE     **
***      PROGRAMMING ENVIRONMENT FOR THE CONSTRUCTION OF      **
***      HP41CV CALCULATOR PROGRAMS.                          **
***                                                           **
***      WITH THE EXCEPTION OF THIS PROGRAM AND THREE OTHERS, ALL OF  **
***      THE SOFTWARE IN THE HP41CV SYSTEM IS DESIGNED TO BE  **
***      TRANSPORTABLE TO OTHER COMPUTER SYSTEMS WITHOUT EXTENSIVE  **
***      PROGRAM MODIFICATION.  THE INSTALLATION UNIQUE COMPONENTS  **
***      ARE IN THE FOLLOWING ROUTINES:                       **
***                                                           **
***               -- HP41CV EXEC      (THE COMMAND ENVIRONMENT)  **
***               -- VERSA FORTRAN    (PLOTTING SUBROUTINE)      **
***               -- PLOTPARM JCL     (PLOT CONTROL JCL)         **
***               -- LBL XEDIT        (EDIT MACRO FOR LOWER CASE LABELS)**
***                                                           **
***      ANOTHER VERSION OF THIS EXEC FOR USE WITH ASCII TERMINALS  **
***      HAS BEEN PROVIDED.  THIS ASCII ORIENTED EXEC MAY BE USED  **
***      BY ENTERING THE COMMAND "HP41C".  THE PRIMARY DIFFERENCES  **
***      BETWEEN THESE TWO EXECS IS THAT FOR ASCII TERMINALS THE  **
***      PRINTING OF THE COMMAND MENU IS SURPRESSED AFTER ONE PRINT  **
***      AND COMMANDS WHICH HAVE MEANING ONLY FOR VIDEO TERMINALS  **
***      SUCH AS FLIST , BROWSE AND XEDIT HAVE BEEN CHANGED TO THE  **
***      CORRESPONDING TYPEWRITER TERMINAL EQUIVALENTS SUCH AS  **
***      LISTFILE, TYPE AND EDIT.                             **
***                                                           **
***                                                           **
***      FOR THE NEW USER OF THE SYSTEM, IT IS RECOMMENDED THAT  **
***      THIS PROGRAM BE EXECUTED SIMPLY BY TYPING THE COMMAND  **
***                                                           **
***                        HP41CV                             **
***                                                           **
***     FOR EXPERIENCED USERS, WHO HAVE NO NEED FOR THE DESCRIPTIVE  **
***     INSTRUCTIONS, THE FOLLOWING COMMAND IS RECOMMENDED:   **
***                                                           **
***                        HP41CV (FN) (1ST COMMAND)          **
***                                                           **
*****************************************************************
&IF /&2 = /HP41 &GOTO -CALLER
&IF /&2 ¬= / &STACK &2
&IF /&3 ¬= / &STACK &3
-CALLER
&IF /&4 ¬= / &STACK &4
&IF /&5 ¬= / &STACK &5
```

```
CP SET PF01 IMMED PF13
CP SET PF02 IMMED PF14
CP SET PF03 IMMED PF15
CP SET PF04 IMMED PF16
CP SET PF05 IMMED PF17
CP SET PF06 IMMED PF18
CP SET PF07 IMMED PF19
CP SET PF08 IMMED PF20
CP SET PF09 IMMED PF21
CP SET PF10 IMMED PF22
CP SET PF11 IMMED PF23
CP SET PF12 IMMED PF24
CP SET PF13 IMMED PF13
CP SET PF14 IMMED PF14
CP SET PF15 IMMED PF15
CP SET PF16 IMMED PF16
CP SET PF17 IMMED PF17
CP SET PF18 IMMED PF18
CP SET PF19 IMMED PF19
CP SET PF20 IMMED PF20
CP SET PF21 IMMED PF21
CP SET PF22 IMMED PF22
CP SET PF23 IMMED PF23
CP SET PF24 IMMED PF24
CP TERMINAL LINEND OFF
CP SPOOL PRINTER CONT
GLOBAL TXTLIB NONIMSL CMSLIB FORTMOD2 MCD2EEH IMSLSP
STATE INSTR CODES A
&IF &RETCODE ¬= 0 &USERMODE = R
&IF &INDEX GT 0 &GOTO -PROGNAM
CLRSCRN
&BEGTYPE -ENDINTRO
                        ***   HP41C CROSS COMPILER ***

 THIS PROGRAM IS USED TO MAKE IT EASIER TO WRITE, DOCUMENT AND REVISE
 PROGRAMS FOR THE HP41C CALCULATOR.  AS OUTPUT, THIS PROGRAM WILL
 PRODUCE OPTICAL BAR CODE FOR DIRECT ENTRY OF YOUR PROGRAM INTO AN
 HP41C OR HP41CV CALCULATOR.


 WARNING     THIS PROGRAM IS PART OF AN CNGOING RESEARCH PROJECT AND AS
 SUCH IS SUBJECT TO CONSTANT REVISION.  WHILE THERE ARE NO KNOWN
 ERRORS, THE PROGRAM HAS NOT BEEN EXTENSIVELY TESTED.  TO INSURE THAT
 ANY ERRORS YOU DETECT ARE PROMPTLY CORRECTED, IT IS IMPORTANT THAT YOU
 SUBMIT AN ERROR REPORT TO THE PROGRAM PROPONENT AS SOON AS POSSIBLE.
```

IN ORDER TO GO FROM A PROGRAM IN YOUR HEAD TO THE FINISHED BAR CODE THERE ARE THREE MAIN STEPS:

(1) EDIT. THE PROGRAM MUST BE PREPARED AS INPUT TO THE CROSS COMPILER. THE EASIEST WAY TO DO THIS IS WITH THE CMS XEDIT FACILITY.

(2) COMPILE. THE PROGRAM MUST BE PROCESSED BY THE CROSS-COMPILER. THE CROSS-COMPILER IS ACTUALLY A FORTRAN PROGRAM WHICH PRODUCES TWO CMS FILES AS OUTPUT. BOTH THESE FILES HAVE THE SAME NAME AS YOUR PROGRAM NAME, BUT HAVE DIFFERENT FILE TYPES. THE "LISTING" FILE SHOWS THE RESULTS OF THE COMPILE STEP INCLUDING ANY ERRORS, AND THE "DATA" FILE IS A FILE OFZERO'S AND ONE'S USED BY THE BAR CODE GENERATOR.

(3) BAR. THE "DATA" FILE FROM THE COMPILE STEP IS USED AS INPUT TO PRODUCE THE ACTUAL BAR CODE. YOU SHOULD NEVER PER-. FORM THIS STEP UNTIL YOUR PROGRAM HAS SUCCESSFULLY COMPILED WITHOUT ERRORS. THIS STEP IS DONE BY THE BATCH PROCESSOR AND IT MAY TAKE SEVERAL HOURS TO GET YOUR FINISHED BAR CODE.

EXECUTION OF THE THREE STEPS NECESSARY TO PRODUCE BAR CODE IS UNDER YOUR CONTROL BY SELECTION OF THE APPROPRIATE STEP FROM A MENU OF COMMANDS WHICH WILL APPEAR AT YOUR TERMINAL SHORTLY.

THE FIRST STEP IN USING THE CROSS-COMPILER IS TO PREPARE THE SOURCE CODE (YOUR PROGRAM) ON CMS DISK. THE FIRST LINE OF A SOURCE CODE FILE MUST CONTAIN THE TITLE OF THE PROGRAM THAT IS TO BE USED AS A LABEL ON THE TOP OF THE BAR CODE. THIS TITLE SHOULD HAVE NO MORE THAN 40 LETTERS. TO HELP YOU REMEMBER THAT THE LABEL OF THE PROGRAM MUST BE THE FIRST LINE, YOU MAY RECEIVE A PROMPT ASKING YOU TO ENTER THE TITLE WHEN YOU FIRST DECLARE A NEW HP41 PROGRAM. AFTER YOU ENTER THE TITLE, YOUR TERMINAL WILL IMMEDIATELY SHIFT TO THE CMS EDITOR AND YOU WILL SEE THE TITLE AS THE FIRST LINE OF THE NEW FILE. THIS IS YOUR CUE TO ENTER THE HP41C PROGRAM THAT YOU HAVE WRITTEN. WHEN YOU EXECUTE A "FILE" COMMAND IN THE EDITOR MODE, THE TERMINAL WILL DISPLAY THE COMMAND MENU. YOU MAY THEN SELECT TO CROSS-COMPILE THE NEW PROGRAM OR ANY OTHER OPTION.

```
WHEN PREPARING  YOUR SOURCE CODE PLEASE  NOTE THAT LOWER  CASE LETTERS
ARE NOT THE SAME AS CAPITALS, AND IN MOST CASES LOWER CASE WILL NOT BE
ACCEPTED. IN ORDER TO MAKE IT EASY TO ENTER THE LOWER CASE ALPHABETIC
LABELS, AN XEDIT MACRO "LBL" HAS BEEN PROVIDED.  TO USE THIS MACRO,
SIMPLY TYPE IN THE XEDIT COMMAND LINE, FOR EXAMPLE:

              LBL LOWER A   (FOR LOWER CASE "A" LABEL)

NOTE THAT THIS XEDIT MACRO ALSO DOES OTHER HELPFUL THINGS, SUCH AS
PROVIDING A BANNER TO HELP LOCATE LABELS AND DIRECTING THE CROSS-
COMPILER TO START A NEW PAGE (INDICATED BY "(" IN COLUMNS 1 AND 2.)
TO AVOID GOING TO A NEW PAGE WHEN YOU WRITE A LABEL, TYPE THE
OPTION "NOPAGE" AS FOLLOWS:

              LBL DOG NOPAGE (FOR AN ALPHA LABEL "DOG")
```



```
IN  THE FUTURE,  YOU  MAY  FIND IT  MORE  CONVIENIENT  TO SKIP  THESE
INSTRUCTIONS AND GO  DIRECTLY TO THE "MENU" OF COMMANDS.    TO DO THIS
SIMPLY TYPE THE  NAME OF THE CMS  FILE WHICH CONTAINS OR  WILL CONTAIN
YOUR  HP41C  SOURCE  CODE  INSTRUCTIONS  AFTER  THE  INVOKING  COMMAND
"HP41C".    AN EASY WAY TO DO THIS IS TO USE THE CMS "FLIST" FACILTITY.
FROM "FLIST" SIMPLY TYPE "PF19" IN THE COMMAND AREA.


NOW, TO BEGIN:
-ENDINTRO
*************************************************************************
***                                                                   ***
***   ESTABLISH A NEW HP41C PROGRAM SOURCE FILE.  INCLUDES TITLE      ***
***   PROMPTING.                                                      ***
***                                                                   ***
*************************************************************************
-NEW
&BEGTYPE -ENDQQ
ENTER CMS FILENAME OF YOUR PROGRAM.....(PF13 OR "STOP" RETURN TO CMS)
-ENDQQ
&SWITCH1 = ON
&READ ARGS
&GOTO -CHECK
-PROGNAM
```

```
&PROGNAME = &1
&PROGTYPE = HP41
&PROGMODE = A1
&SWITCH1 = OFF
STATE &PROGNAME &PROGTYPE &PROGMODE
&IF &RETCODE = 0 &GOTO -DISPLAY
CLRSCRN
&BEGTYPE -ENDINTRO2

ENTER THE LABEL YOU WISH TO HAVE PRINTED AT THE TOP OF THE BARCODE.
-ENDINTRO2
&READ ARGS
&STACK I &1 &2 &3 &4 &5 &6 &7 &8 &9 &10
&STACK LBL &PROGNAME
&STACK SET TABS 1 20 25 35 45 55 65
&STACK SET TRUNC 57
&STACK I
XEDIT &PROGNAME &PROGTYPE &PROGMODE
*************************************************************************
**                                                                     **
**                  COMMAND DISPLAY ROUTINE                            **
**                                                                     **
*************************************************************************
-DISPLAY
&IF /&SWITCH1 = /ON &GOTO -NEW

&IF /ASCII = /YES &GOTO -ENDDISP
CLRSCRN
&TYPE HP41C CROSS COMPILER ..... &PROGNAME .....EDITION=17 SEP 81
&BEGTYPE -ENDDISP
SELECT DESIRED COMMAND FROM THE FOLLOWING:

PF-KEY    COMMAND  CODE   ACTION TAKEN BY PROGRAMMING  COMMAND SYSTEM

PF13       STOP      S    GETS YOU OUT OF THE HP41C CROSS COMPILER
PF14       HELP      H    SHORT EXPLANATION OF HOW TO USE THE CROSS COMPILER
PF15       ENTER     E    INTERACTIVE PROGRAM ENTRY (NO FILE CREATED)
PF16       BAR       B    SUBMIT JOB FOR PHYSICAL PRODUCTION OF BAR CODE
PF17       NEW       N    BEGIN WORK ON A NEW PROGRAM OR NAMED SUBROUTINE
PF18       DIREC     D    DIRECTORY OF COMMANDS
PF19       LIST      L    DISPLAY  NAMES   OF HP41C PROGRAMS ON DISK
PF20       OCOMP    C O   OFFLINE COMPILE AND AUTO GENERATION OF BAR CODE
PF21       PRINT     P    PRODUCE A HARDCOPY PRINTED LISTING OF THE PROGRAM
PF22        *        *    RESERVED FOR FUTURE USE BY HP41 EMMULATOR
PF23       COMP      C    COMPILE A SOURCE LISTING ON CMS DISK
PF24       XEDIT     X    EDIT THE PROGRAM USING THE CMS FULL-SCREEN EDITOR
           ERASE          ERASE THE SOURCE FILE,LISTING FILE AND TEXT FILE
           CMS            ALLOWS EXECUTION OF ANY VALID CMS COMMAND
```

```
          CP              ALLOWS EXECUTION OF ANY VALID CP COMMAND
-ENDDISP
&TYPE INPUT COMMAND:
&READ ARGS
CLRSCRN
*************************************************************************
**                                                                     **
**                    COMMAND CHECK ROUTINE                            **
**                                                                     **
*************************************************************************
-CHECK
&IF /CMS = /&1 &GOTO -CMSCMD
&IF /CP = /&1 &GOTO -CPCMD
&IF /PF13 = /&1 &GOTO -EXIT
&IF /PF14 = /&1 &GOTO -HELP
&IF /PF15 = /&1 &GOTO -ENTER
&IF /PF16 = /&1 &GOTO -SUBMIT
&IF /PF17 = /&1 &GOTO -NEW
&IF /PF18 = /&1 &GOTO -DISPLAY
&IF /PF19 = /&1 &GOTO -LISTFIL
&IF /PF20 = /&1 &GOTO -OCOMP
&IF /PF21 = /&1 &GOTO -TYPE
&IF /PF22 = /&1 &GOTO -NOTYET
&IF /PF23 = /&1 &GOTO -COMPILE
&IF /PF24 = /&1 &GOTO -XEDIT
&IF /STOP = /&1 &GOTO -EXIT
&IF /HELP = /&1 &GOTO -HELP
&IF /ENTER = /&1 &GOTO -ENTER
&IF /BAR = /&1 &GOTO -SUBMIT
&IF /NEW = /&1 &GOTO -NEW
&IF /DIREC = /&1 &GOTO -DISPLAY
&IF /LIST = /&1 &GOTO -LISTFIL
&IF /OCCMP = /&1 &GOTO -OCOMP
&IF /PRINT = /&1 &GOTO -TYPE
&IF /COMP = /&1 &GOTO -COMPILE
&IF /XEDIT = /&1 &GOTO -XEDIT
&IF /ERASE = /&1 &GOTO -ERASE
&IF /S = /&1 &GOTO -EXIT
&IF /H = /&1 &GOTO -HELP
&IF /E = /&1 &GOTO -ENTER
&IF /3 = /&1 &GOTO -SUBMIT
&IF /N = /&1 &GOTO -NEW
&IF /D = /&1 &GOTO -DISPLAY
&IF /P = /&1 &GOTO -TYPE
&IF /C = /&1 &IF /O = /&2 &GOTO -OCOMP
&IF /C = /&1 &GOTO -COMPILE
&IF /X = /&1 &GOTO -XEDIT
&IF /&1 = /FILEDEF &GOTO -INNER
```

```
&IF /&1 = /DATA &GOTO -INNER
&IF /&SWITCH1 = /ON &GOTO -PROGNAM
&TYPE ?? &1 &2 &3 &4 &5 UNRECOGNIZED
-ENDCHECK &GOTO -ENDDISP
*****************************************************************
***                                                           **
***   PROCESS CMS OR CP COMMANDS PASSED TO THIS EXEC.         **
***                                                           **
***                                                           **
*****************************************************************
-CMSCMD &ARG = &RANGE OF & 2 &N
&TRACE ON
&COMMAND &ARG
&TRACE OFF
&GOTO -ENDDISP
-CPCMD &ARG = &RANGE OF & 2 &N
&TRACE ON
CP &ARG
&TRACE OFF
&GOTO -ENDDISP
-XEDIT
&STACK SET TABS 1 20 25 35 45 55 65
&STACK SET TRUNC 57
XEDIT &PROGNAME &PROGTYPE &PROGMODE
&GOTO -DISPLAY
*****************************************************************
**                                                           **
**     LIST HP41C PROGRAM FILES ON CMS DISK)                 **
**                                                           **
*****************************************************************
-LISTFIL
FLIST * HP41 A
&GOTO -DISPLAY
*****************************************************************
**                                                           **
**                        COMPILE                            **
**                                                           **
*****************************************************************
-COMPILE
FILEDEF 05 DISK &PROGNAME &PROGTYPE
FILEDEF 06 DISK &PROGNAME LISTING
FILEDEF 04 DISK &PROGNAME DATA
FILEDEF 02 DISK INSTR CODES &USERMODE
&TYPE CROSS-COMPILE BEGINS..
HPCRCSS
BROWSE &PROGNAME LISTING
&GOTO -DISPLAY
*****************************************************************
```

```
**                                                                              **
**                    OFFLINE COMPILE                                           **
**                                                                              **
********************************************************************************
-OCCMP
ERASE &PROGNAME DATA
FILEDEF 05 DISK &PROGNAME &PROGTYPE
FILEDEF 06 DISK &PROGNAME LISTING
FILEDEF 04 DISK &PROGNAME DATA
FILEDEF 02 DISK INSTR CODES &USERMODE
&TYPE CROSS-COMPILE BEGINS..
HPCROSS
PRINT &PROGNAME LISTING (UP
STATE &PROGNAME DATA
&IF &RETCODE = 0 &GOTO -SUBMIT
&TYPE  COMPILE OF &PROGNAME WAS NOT SUCCESSFUL.
&GOTO -ENDDISP
********************************************************************************
***                                                                          ***
***    USING THE INTERACTIVE MODE, ENTER A NEW PROGRAM.                      ***
***                                                                          ***
********************************************************************************
-ENTER
&BEGTYPE -ENDCAUTION
CAUTION.  USE OF THE INTERACTIVE ENTRY MODE REQUIRES THAT YOU PROPERLY
          CONTROL THE USE OF UPPER AND LOWER CASE.  ALSO, INTERACTIVE
          ENTRY DOES NOT CREATE A PERMANENT RECORD OF YOUR SOURCE CODE
          INPUT.  SHOULD A REVISION BE REQUIRED, YOU WOULD NEED TO
          RE-ENTER THE ENTIRE PROGRAM.  FOR THESE REASONS YOU MAY WISH
          TO XEDIT A SOURCE CODE FILE FIRST, AND THEN SUBMIT THIS FILE
          FOR CROSS-COMPILATION WITH THE "COMP" COMMAND.

          DO YOU WISH TO PROCEED WITH INTERACTIVE ENTRY? (Y/N)

INPUT RESPONSE:
-ENDCAUTION
&READ ARGS
&IF /&1 ¬= /Y  &GOTO -DISPLAY
CLRSCRN
&TYPE FIRST ENTER THE LABEL YOU WISH TO BE PRINTED AT THE TOP OF THE
&TYPE       BAR CODE.
&TYPE THEN  ENTER THE INSTRUCTIONS IN YOUR PROGRAM (IN UPPER CASE EXCEPT
&TYPE       FOR LOWER CASE ALPHABETIC LABELS WHICH ARE ALLOWED.)
&TYPE
&TYPE INPUT:
FILEDEF 04 DISK &PROGNAME DATA
FILEDEF 02 DISK INSTR CODES &USERMODE
HPCROSS
&GOTO -ENDDISP
```

```
*****************************************************************
***                                                           **
***     DISPLAY A MESSAGE THAT FUNCTION IS NOT AVAILABLE.     **
***                                                           **
*****************************************************************
-NOTYET
CLRSCRN
&BEGTYPE -ENDYET

THE FUNCTION YOU HAVE REQUESTED IS NOT YET AVAILABLE.  IF YOU HAVE ANY
IDEAS THAT SHOULD BE INCLUDED HERE, PLEASE CONTACT THE PROPONENT.

THANK YOU.
-ENDYET
&GOTO -ENDDISP
*****************************************************************
**                                                           **
**                    TYPE LISTING FILE                      **
**                                                           **
*****************************************************************
-TYPE
PRINT &PROGNAME LISTING (UP
&GOTO -DISPLAY
*****************************************************************
**                                                           **
**            ERASE SOURCE, LISTING AND TEXT FILES           **
**                                                           **
*****************************************************************
-ERASE
ERASE &PROGNAME LISTING
ERASE &PROGNAME DATA
ERASE LOAD MAP
&TYPE WARNING     DO YOU WISH TO ERASE THE SOURCE CODE(YES/NO)?
&READ VARS &ANSW
&IF /&ANSW ¬= /YES &GOTO -DISPLAY
ERASE &PROGNAME &PROGTYPE &PROGMODE
&GOTO -DISPLAY
*****************************************************************
**                                                           **
**                  SUBMIT TO MVS FOR BATCH PROCESSING       **
**                                                           **
*****************************************************************
-SUBMIT
-TRYSUBMIT
&PERM = SUBMIT
&BEGTYPE -ENDSUBM
ENTER JOB NAME AND USERID:
-ENDSUBM
```

```
&READ VARS &JN &USERID
&JN = &PIECE OF &JN 1 8
&USERID = &PIECE OF &USERID 1 4
&STACK 1 //&JN JOB (&USERID ,1011),'HP41CV BAR CODE',CLASS=A
&STACK C / ,1011)/,1011)/
&STACK 1 // EXEC FRTXCLGP
&STACK 1 //FORT.SYSIN DD *
&STACK GET VERSA FORTRAN &USERMODE
&STACK 1 //GO.PLOTPARM DD *
&STACK GET PLOTPARM JCL  &USERMODE
&STACK 1 //GO.SYSIN DD *
&STACK GET &PROGNAME DATA
&STACK 1 /*
&STACK FILE
XEDIT &PROGNAME JCL
EXEC SUBMIT &PROGNAME JCL
ERASE &PROGNAME JCL
&GOTO -DISPLAY
*************************************************************************
**                                                                     **
**                    PRINT INSTRUCTIONS                               **
**                                                                     **
*************************************************************************
-HELP
&BEGTYPE -ENDHELP
```


HP41C CROSS COMPILER COMMAND PROCESSOR

YOU ARE CURRENTLY EXECUTING A CMS EXEC FILE THAT MAKES IT EASY TO INVOKE THE HP41C CROSS COMPILER AND WRITE PROGRAMS USING CMS AND THE IBM 3278 DISPLAY TERMINAL. COMMON PROGRAMMING REQUIREMENTS SUCH AS EDITING CAN BE ACCOMPLISHED IN THREE WAYS:

- --USING THE PROGRAMMED FUNCTION KEYS (PF KEYS)
- --USING A SHORT COMMAND WORD
- --USING A ONE OR TWO LETTER MNEMONIC CODE

THE COMMAND ACTIONS AND THEIR ASSOCIATED PF KEYS AND CODES ARE ALL GIVEN IN A DIRECTORY WHICH IS DISPLAYED WHEN THE COMMAND PROCESSOR IS WAITING FOR YOUR INPUT. MORE DETAILS ABOUT THE AVAILABLE COMMANDS FOLLOWS:

PF13 STOP S THIS COMMAND IS USED WHEN YOU WISH TO STOP PROCESSING

			HP41C PROGRAMS AND RETURN TO CMS. IF YOU ARE EXECUTING A FUNCTION THAT WAS INVOKED FROM THE COMMAND MENU, IN MOST CASES PF13 WILL RETURN YOU TO THE MENU, AND BY PRESSING PF13 AGAIN YOU WILL RETURN TO CMS.
PF14	HELP	H	THIS COMMAND IS USED TO DISPLAY THE DETAILED EXPLANATION OF THE MENU COMMAND PROCESSOR AND ITS AVAILABLE COMMANDS. IF YOU HAVE QUESTIONS ABOUT THE PROCESS OF WRITING ACTUAL HP41C PROGRAMS YOU SHOULD CONSULT THE HP41 OWNER'S HANDBOOK.
PF15	ENTER	E	THIS COMMAND IS USED TO ENTER A PROGRAM USING THE CROSS-COMPILER IN AN INTERACTIVE MODE. THE ADVANTAGE OF THIS MODE IS THAT ANY SYNTACTICAL ERRORS IN THE HP41C PROGRAM ARE IMMEDIATELY IDENTIFIED BY THE CROSS-COMPILER AND AN ERROR MESSAGE IS SHOWN ON THE SCREEN. THE DISADVANTAGE IS THAT THE USER IS TOTALLY RESPONSIBLE FOR UPPER AND LOWER CASE BEING ENTERED PROPERLY.
PF16	BAR	B	THIS COMMAND IS USED ONCE THE HP41C PROGRAM IS WRITTEN AND COMPILED WITHOUT ERRORS. IT SUBMITS A JOB TO MVS BATCH FOR THE PHYSICAL PRODUCTION OF THE BAR CODE.
PF17	NEW	N	THIS COMMAND IS USED TO DIRECT THE ATTENTION OF THE COMMAND PROCESSOR TO A NEW HP41 PROGRAM SOURCE FILE. WHEN USED TO INITIATE NEW HP41C PROGRAMS, IT AUTOMATICALLY INSURES THAT A NEW FILE IS CREATED WITH FILETYPE "HP41" AND PROMPTS THE USER FOR THE PROGRAM TITLE WHICH IS THE MANDATORY FIRST LINE OF EVERY HP41C SOURCE CODE FILE.
PF18	DIREC	D	THIS COMMAND DISPLAYS THE FULL COMMAND MENU. IT HAS PRIMARY USE WHEN YOU FINISH AN OPERATION THAT FILLS THE SCREEN WITH TEXTUAL MATTER AND YOU RECEIVE ONLY THE PROMPT "INPUT COMMAND".
PF19	LIST	L	THIS COMMAND DISPLAYS "FLIST" FOR THOSE HP41C PROGRAMS THAT ARE ACTIVE ON YOUR A DISK. FROM THIS LIST, YOU CAN ERASE OLD PROGRAMS TO RELEASE DISK STORAGE, CHANGE THE NAME OF PROGRAMS, OR EXAMINE THE CONTENTS OF ANY PROGRAM.
PF20	CCOMP	C O	THIS COMMAND IS USED TO PRODUCE AN "OFFLINE" COMPILE. THE PROGRAM LISTING IS AUTOMATICALLY PRINTED IN HARD COPY ON THE HIGH SPEED PRINTER. IF THE COMPILE WAS WITHOUT ERROR THE BAR CODE IS AUTOMATICALLY PRODUCED.

PF21	PRINT	P	THIS COMMAND PRINTS A COPY OF THE "LISTING" FILE ON THE HIGH SPEED PRINTER. IF YOU WISH TO HAVE A PRINTED COPY OF THE SOURCE CODE WITHOUT THE CROSS-COMPILER'S FEEDBACK, IT IS BEST TO SIMPLY PRINT THE SOURCE CODE CMS FILE BY ISSUING THE CMS PRINT COMMAND.
PF22	GO	G	THIS COMMAND IS USED TO INVOKE THE HP41C EMMULATOR PROGRAM WHICH ALLOWS YOU TO TEST EXECUTION OF THE PROGRAM ON THE LARGE COMPUTER. THE EMULATION PROGRAM WILL EXECUTE THE PROGRAM EXACTLY AS YOUR CALCULATOR WOULD. THIS COMMAND HAS NOT BEEN IMPLEMENTED AS OF 17 SEP 81.
PF23	COMP	C	THIS COMMAND IS USED TO INVOKE THE CROSS COMPILER TO TRANSLATE AN HP41C PROGRAM WRITTEN ON CMS DISK IN SOURCE CODE FORM. AFTER THE COMPILE THE USER IS AUTOMATICALLY PLACED IN THE CMS BROWSE MODE FOR THE OUTPUT "LISTING" FILE THAT RESULTED FROM THE COMPILE.
PF24	XEDIT	X	THIS COMMAND IS USED TO INVOKE THE FULL-SCREEN EDITOR TO MAKE MODIFICATIONS TO THE HP41C SOURCE CODE FILE.

IF YOU HAVE PROBLEMS USING THIS COMMAND PROCESSOR OR HAVE A SUGGESTION FOR IMPROVEMENT, PLEASE CONTACT THE PROPONENT FOR THE HP41C SYSTEM.

```
-ENDHELP
&GOTO -ENDDISP
**************************************************************
**                                                          **
**                    EXIT COMMAND PROCESSOR                **
**                                                          **
**************************************************************
-EXIT
CP SPOOL PRINTER CLOSE NOCONT
CLRSCRN
&EXIT
```

```
C*************************************************************************HPC00010
C**                                                                      **HPC00020
C**    THIS IS THE MAIN ROUTINE FOR THE HP41C CROSS-COMPILER.            **HPC00030
C**                                                                      **HPC00040
C**    INPUT TO THIS PROGRAM IS A SUPERSET OF HP41C INSTRUCTIONS. THE    **HPC00050
C**    REGULAR INSTRUCTIONS ARE WELL DOCUMENTED IN THE HP41C OWNER'S     **HPC00060
C**    HANDBOOK AND PROGRAMMING GUIDE (SEE ESPECIALLY THE INDEX ON       **HPC00070
C**    PAGE 271).  IN ADDITION TO THESE REGULAR INSTRUCTIONS, THE        **HPC00080
C**    FOLLOWING COMMANDS ARE SUPPORTED:                                 **HPC00090
C**                                                                      **HPC00100
C**       (       INDICATES A COMMENT CARD (NO INSTRUCTIONS GENERATED)   **HPC00110
C**       XROM    SUBROUTINE CALL TO A READ ONLY MEMORY                  **HPC00120
C**       LBL     KEY ASSIGNMENTS MAY BE MADE AS PART OF ALPHA LBL       **HPC00130
C**                                                                      **HPC00140
C**    OUTPUT OF THIS PROGRAM IS AN INTERMEDIATE FILE OF ZERO'S AND      **HPC00150
C**    ONE'S REPRESENTING HP41C MACHINE INSTRUCTIONS.  THIS FILE WILL    **HPC00160
C**    NORMALLY BE PASSED TO A FORTRAN PROGRAM WHICH DRAWS HP41C BAR     **HPC00170
C**    CODE ON A HIGH RESOLUTION PLOTTER.                                **HPC00180
C**                                                                      **HPC00190
C**                                                                      **HPC00200
C*************************************************************************HPC00210
      INTEGER ASGN$,EQ$,POS$,SEG$,PARS$,CON$,IN$,COMP$,FIND$,LCUT$        HPC00220
      INTEGER TRIM$                                                       HPC00230
      COMMON/TEXT/IDIM,IPRT                                               HPC00240
      COMMON/FLAGS/DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2       HPC00250
      COMMON/CNTR/P1,P2,P3,P4,P5,P6,P7,P8,P9,S1,S2                        HPC00260
      LOGICAL DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2            HPC00270
      INTEGER*4 P1,P2,P3,P4,P5,P6,P7,P8,P9,S1,S2                          HPC00280
      COMMON/TABLE/INST$,LINST,CODE,NINST                                 HPC00290
      INTEGER*2 INST$(6,111)                                              HPC00300
      INTEGER*4 LINST(111),CODE(111),NINST                                HPC00310
      INTEGER*2 T$(80),TITLE$(133)                                        HPC00320
      INTEGER*4 LT,LTITLE,MTITLE                                          HPC00330
      INTEGER*4 FUNC$/'MAIN'/                                             HPC00340
      INTEGER*2 COMENT/'('/                                               HPC00350
      INTEGER*4 UNDER(15)/15*'____'/                                      HPC00360
      INTEGER*4 M(8000)/8000*-997-/                                       HPC00370
      INTEGER*4 M1/1/,B1/1/                                               HPC00380
      INTEGER*4 LINCNT/0/,PAGE/72/                                        HPC00390
      LOGICAL ERROR/.FALSE./                                              HPC00400
      NUMPGE=1                                                            HPC00410
      LTITLE=80                                                           HPC00420
      MTITLE=1                                                            HPC00430
      IDIM=80                                                             HPC00440
      MAX=2000                                                            HPC00450
      NINST=111                                                           HPC00460
      PDIGIT=.FALSE.                                                      HPC00470
      PALPHA=.FALSE.                                                      HPC00480
```

```
      DONE=.FALSE.                                                          HPC00490
C                                                                           HPC00500
C                                                                           HPC00510
C                                                                           HPC00520
      READ(2,101) IPRT,PAGE                                                 HPC00530
      READ(2,9101)(TITLE$(JJ),JJ=1,25)                                      HPC00540
9101  FORMAT(25A1)                                                          HPC00550
101   FORMAT(12I5)                                                          HPC00560
      DO 5 I=1,NINST                                                        HPC00570
         READ(2,102)(INST$(J,I),J=1,6),CODE(I),LINST(I)                     HPC00580
102      FORMAT(6A1,4X,I5,10X,I5)                                           HPC00590
5     CONTINUE                                                              HPC00600
C                                                                           HPC00610
C                                                                           HPC00620
C                                                                           HPC00630
C                                                                           HPC00640
      READ(5,103) (TITLE$(I),I=26,IDIM)                                     HPC00650
103   FORMAT(75A1)                                                          HPC00660
C                                                                           HPC00670
C                                                                           HPC00680
C                                                                           HPC00690
C                                                                           HPC00700
C                                                                           HPC00710
      LENGTH=0                                                              HPC00720
      DO 16 I=1,MAX                                                         HPC00730
C                                                                           HPC00740
C            ( I=THE INSTR NUMBER, J=CHARACTER IN INSTR)                    HPC00750
C                                                                           HPC00760
C                                                                           HPC00770
C                                                                           HPC00780
C     ATTEMPT TO READ A TEXT STRING.                                        HPC00790
C                                                                           HPC00800
      IF(IPRT.GE.20)WRITE(6,292) UNDER                                      HPC00810
292   FORMAT('1','NEXT INSTRUCTION:',15A4,//)                               HPC00820
C                                                                           HPC00830
      IF(IN$(T$,LT,5)) 14,12,12                                             HPC00840
C                                                                           HPC00850
C                                                                           HPC00860
C     GO TO THE FOLLOWING INSTRUCTIONS IF A CHARACTER STRING FOUND          HPC00870
C                                                                           HPC00880
C                                                                           HPC00890
C                                                                           HPC00900
C                                                                           HPC00910
C     CHECK FOR A COMMENT CARD AND/OR PAGE EJECT                            HPC00920
C                                                                           HPC00930
C          *** TWO "COMENT" CHARACTERS IN POSITION 1 AND 2 OF AN INPUT      HPC00940
C              LINE ARE CONSIDERED A MANDATORY PAGE EJECT PRAGMA.  ***      HPC00950
C                                                                           HPC00960
```

```
C                                                                       HPC00970
12    IF(T$(1).NE.COMENT)GOTO 13                                        HPC00980
      IF(MOD(LINCNT,PAGE).EQ.0.OR.(T$(2).EQ.COMENT.AND.LT.GE.2))        HPC00990
     1     CALL NEWPG$(LINCNT,NUMPGE,TITLE$,LTITLE,1)                   HPC01000
      LINCNT=LINCNT+1                                                   HPC01010
      WRITE(6,268) (T$(J),J=1,LT)                                       HPC01020
268   FORMAT('                ',110A1)                                  HPC01030
      IF(IPRT.GE.10)WRITE(6,263)                                        HPC01040
263   FORMAT(' FOUND COMMENT CARD.  NOTHING MORE DONE.')                HPC01050
      GOTO 16                                                           HPC01060
C                                                                       HPC01070
C                                                                       HPC01080
C                                                                       HPC01090
C     IF NOT A COMMENT, INCREMENT THE INSTRUCTION COUNTER AND PRINT     HPC01100
C     THE INSTRUCTION.                                                  HPC01110
C                                                                       HPC01120
13    LENGTH=LENGTH+1                                                   HPC01130
      IF(MOD(LINCNT,PAGE).EQ.0)                                         HPC01140
     1     CALL NEWPG$(LINCNT,NUMPGE,TITLE$,LTITLE,1)                   HPC01150
C                                                                       HPC01160
      LINCNT=LINCNT+1                                                   HPC01170
      WRITE(6,269)LENGTH,(T$(J),J=1,LT)                                 HPC01180
269   FORMAT('        ',I4,' ',110A1)                                   HPC01190
C                                                                       HPC01200
C                                                                       HPC01210
C     TRIM OFF TRAILING COMMENTS                                        HPC01220
C                                                                       HPC01230
      IF(FIND$(COMENT,1,T$,LT,LOC)) 6000,9915,9914                      HPC01240
9914  LT=LOC-1                                                          HPC01250
      IF(TRIM$(T$,LT)) 6000,9916,9915                                   HPC01260
9916  CONTINUE                                                          HPC01270
      GOTO 16                                                           HPC01280
9915  CONTINUE                                                          HPC01290
C                                                                       HPC01300
C                                                                       HPC01310
C                                                                       HPC01320
C     COMPILE THE TEXT INSTRUCTION.                                     HPC01330
C                                                                       HPC01340
      IF(COMP$(T$,LT,M,M1)) 15,16,20                                    HPC01350
15    ERROR=.TRUE.                                                      HPC01360
16    CONTINUE                                                          HPC01370
C                                                                       HPC01380
C                                                                       HPC01390
C                                                                       HPC01400
C     GOTO THE FOLLOWING INSTRUCTIONS IF END OF FILE ENCOUNTERED        HPC01410
C                                                                       HPC01420
14    WRITE(6,259)                                                      HPC01430
259   FORMAT(' ********************END OF FILE********************')   HPC01440
```

```
                                                                        HPC01450
C                                                                       HPC01460
CCC                                                                     HPC01470
CCC     GOTO THE FOLLOWING INSTRUCTIONS IF END COMPILATION              HPC01480
CCC                                                                     HPC01490
20        IF(ERROR) STOP                                                HPC01500
CCC                                                                     HPC01510
CCC                                                                     HPC01520
CCC     CALL THE BAR CODE GENERATOR.                                    HPC01530
CCC                                                                     HPC01540
30        MSAVE=M1                                                      HPC01550
          B1=1                                                          HPC01560
          IBAR=BSTR$(M,M1,ITOT,TITLE$)                                  HPC01570
          WRITE(6,301) ITOT                                             HPC01580
301       FORMAT(' END HP41C CROSS COMPILE',I5,' BYTES IN TOTAL PROGRAM')HPC01590
C                                                                       HPC01600
CCC                                                                     HPC01610
CCC                                                                     HPC01620
C                                                                       HPC01630
          STOP                                                          HPC01640
C                                                                       HPC01650
CCC                                                                     HPC01660
CCC                                                                     HPC01670
CCC     ERROR HANDLING SECTION FOLLOWS                                  HPC01680
C                                                                       HPC01690
6000    WRITE(6,6001) FUNC$                                             HPC01700
6001    FORMAT(' *** STRING LENGTH ERROR *** ',A4)                      HPC01710
        MAIN$=0                                                         HPC01720
        RETURN                                                          HPC01730
6002    WRITE(6,6003) FUNC$                                             HPC01740
6003    FORMAT(' *** FUNCTION CALL ERROR *** ',A4)                      HPC01750
        MAIN$=0                                                         HPC01760
        RETURN                                                          HPC01770
        END                                                             HPC01780
```

```
      INTEGER FUNCTION AIN$(INOPER,B)                                    AIN00010
C*****************************************************************     *AIN00020
C**                                                                   **AIN00030
C**    THIS FUNCTION CONVERTS A DECIMAL NUMBER <=256 INTO A BINARY     **AIN00040
C**    NUMBER, WITH THE VALUES OF THE BINARY DIGITS STORED IN          **AIN00050
C**    SUCESSIVE ELEMENTS OF AN 8 ELEMENT ARRAY OF INTEGERS.           **AIN00060
C**                                                                    **AIN00070
C**    THIS FUNCTION IS CALLED FROM BSTR$ IN THE HP-41CV COMPILER.     **AIN00080
C**                                                                    **AIN00090
C**                                                                    **AIN00100
C**                                                                    **AIN00110
C**                                                                    **AIN00120
C**    THE RETURN VALUE OF THE FUNCTION AIN$ IS SET AS FOLLOWS:        ** AIN00130
C**          0   =  CONTINUE TO COMPILE                               **AIN00140
C**         -1   =  AN ERROR IN COMPILING THE INSTRUCTION.             **AIN00150
C**                                                                    **AIN00160
C**                                                                    **AIN00170
C*****************************************************************     AIN00180
      IMPLICIT INTEGER(A-Z)                                              AIN00190
      COMMON/TEXT/IDIM,IPRT                                              AIN00200
      INTEGER*4 FUNC$/'AIN'/                                             AIN00210
      INTEGER*2 B(8)                                                     AIN00220
      OPERND=INOPER                                                      AIN00230
C                                                                        AIN00240
CC                                                                       AIN00250
CC                                                                       AIN00260
CC    CHECK FOR VALID ENTRY  OPERAND                                     AIN00270
C                                                                        AIN00280
      IF((OPERND.GT.255).OR.(OPERND.LT.0)) GOTO 6000                     AIN00290
C                                                                        AIN00300
CC                                                                       AIN00310
CC                                                                       AIN00320
CC    CONVERT THE FIRST    BINARY DIGIT                                  AIN00330
C                                                                        AIN00340
      D1=OPERND-128                                                      AIN00350
      IF(D1) 100,110,110                                                 AIN00360
100   B(1)=0                                                             AIN00370
      GOTO 120                                                           AIN00380
110   B(1)=1                                                             AIN00390
      OPERND=D1                                                          AIN00400
C                                                                        AIN00410
C                                                                        AIN00420
C     CONVERT THE SECOND   BINARY DIGIT                                  AIN00430
C                                                                        AIN00440
120   D2=OPERND-64                                                       AIN00450
      IF(D2) 200,210,210                                                 AIN00460
200   B(2)=0                                                             AIN00470
      GOTO 230                                                           AIN00480
```

```
210       B(2)=1                                                        AIN00490
          OPERND=D2                                                     AIN00500
C                                                                       AIN00510
CCC                                                                     AIN00520
CC      CONVERT THE THIRD    BINARY DIGIT                               AIN00530
C                                                                       AIN00540
230       D3=OPERND-32                                                  AIN00550
          IF(D3) 300,310,310                                            AIN00560
300       B(3)=0                                                        AIN00570
          GOTO 340                                                      AIN00580
310       B(3)=1                                                        AIN00590
          OPERND=D3                                                     AIN00600
C                                                                       AIN00610
CCC                                                                     AIN00620
CC      CONVERT THE FOURTH   BINARY DIGIT                               AIN00630
C                                                                       AIN00640
340       D4=OPERND-16                                                  AIN00650
          IF(D4) 400,410,410                                            AIN00660
400       B(4)=0                                                        AIN00670
          GOTO 450                                                      AIN00680
410       B(4)=1                                                        AIN00690
          OPERND=D4                                                     AIN00700
C                                                                       AIN00710
CCC                                                                     AIN00720
CC      CONVERT THE FIFTH    BINARY DIGIT                               AIN00730
C                                                                       AIN00740
450       D5=OPERND-8                                                   AIN00750
          IF(D5) 500,510,510                                            AIN00760
500       B(5)=0                                                        AIN00770
          GOTO 560                                                      AIN00780
510       B(5)=1                                                        AIN00790
          OPERND=D5                                                     AIN00800
C                                                                       AIN00810
CCC                                                                     AIN00820
CC      CONVERT THE SIXTH    BINARY DIGIT                               AIN00830
C                                                                       AIN00840
560       D6=OPERND-4                                                   AIN00850
          IF(D6) 600,610,610                                            AIN00860
600       B(6)=0                                                        AIN00870
          GOTO 670                                                      AIN00880
610       B(6)=1                                                        AIN00890
          OPERND=D6                                                     AIN00900
C                                                                       AIN00910
CCC                                                                     AIN00920
CC      CONVERT THE SEVENTH  BINARY DIGIT                               AIN00930
C                                                                       AIN00940
670       D7=OPERND-2                                                   AIN00950
          IF(D7) 700,710,710                                            AIN00960
```

```
700       B(7)=0                                                        AIN00970
          GOTO 780                                                      AIN00980
710       B(7)=1                                                        AIN00990
          OPERND=D7                                                     AIN01000
C                                                                       AIN01010
C                                                                       AIN01020
C       CONVERT THE EIGHTH   BINARY DIGIT                               AIN01030
C                                                                       AIN01040
780       D8=OPERND-1                                                   AIN01050
          IF(D8) 800,810,6000                                           AIN01060
800       B(8)=0                                                        AIN01070
          GOTO 1000                                                     AIN01080
810       B(8)=1                                                        AIN01090
C                                                                       AIN01100
C                                                                       AIN01110
C                                                                       AIN01120
C       WRITE OUT CONVERSION IF NECESSARY AND RETURN                    AIN01130
C                                                                       AIN01140
1000    IF(IPRT.GE.20) WRITE(6,66) INOPER,(B(I),I=1,8)                  AIN01150
66      FORMAT(' TRACE          AIN$   OPERAND=',I5,' BINARY= ',8I1)    AIN01160
        AIN$=0                                                          AIN01170
        RETURN                                                          AIN01180
C                                                                       AIN01190
C                                                                       AIN01200
C                                                                       AIN01210
C                                                                       AIN01220
C       ERROR HANDLING SECTION FOLLOWS                                  AIN01230
C                                                                       AIN01240
6000    WRITE(6,6001) FUNC$                                             AIN01250
6001    FORMAT(' ***** CONVERSION ERROR  ****** ',A4)                   AIN01260
        WRITE(6,6002) INOPER                                            AIN01270
6002    FORMAT(' ERROR IN      AIN$   OPERAND=',I5)                     AIN01280
        AIN$=-1                                                         AIN01290
        RETURN                                                          AIN01300
        END                                                             AIN01310
```

```
      INTEGER FUNCTION ALPH$(A$,LA,M,M1)                                ALP00010
C*****************************************************************     *ALP00020
C**                                                                   **ALP00030
C**   THIS FUNCTION INTERPRETS ALPHABETIC CHARACTERS INTO HP41C KEY    **ALP00040
C**   CODES.                                                          **ALP00050
C**                                                                   **ALP00060
C**    THE RETURN VALUE OF THE FUNCTION ALPH$ IS SET AS FOLLOWS:      **ALP00070
C**          0  =  CONTINUE TO COMPILE                                **ALP00080
C**         -1  =  AN ERROR IN COMPILING THE INSTRUCTION.             **ALP00090
C**                                                                   **ALP00100
C**                                                                   **ALP00110
C*****************************************************************     *ALP00120
      IMPLICIT INTEGER(A-Z)                                             ALP00130
      COMMON/TEXT/IDIM,IPRT                                             ALP00140
      COMMON/FLAGS/DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2     ALP00150
      LOGICAL DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2          ALP00160
      LOGICAL DONE,PDIGIT,PALPHA,DIGIT,ALPHA                            ALP00170
      INTEGER*2 A$(IDIM)                                                ALP00180
      INTEGER*2 BLNK/' '/,QUOTE/'"'/                                    ALP00190
      INTEGER*4 FUNC$/'ALPH'/                                           ALP00200
      INTEGER*4 M(1)                                                    ALP00210
      INTEGER*4 FUNC$/'COMP'/                                           ALP00220
      INTEGER*2 C$(60)/' ','#','$','%','&','*','+',',','-','.','/','0', ALP00230
     2                '1','2','3','4','5','6','7','8','9',':',';','<', ALP00240
     3                '=','>','?','@','A','B','C','D','E','F','G','H', ALP00250
     4                'I','J','K','L','M','N','O','P','Q','R','S','T', ALP00260
     5                'U','V','W','X','Y','Z','[',' ',' ',' ',' ',' '/ ALP00270
      INTEGER*4 C2(60)/32,29,36,37,126,42,43,44,45,46,47,48,49,50,51,52,ALP00280
     2                53,54,55,56,57,58,59,60,61,62,63,13,65,66,67,68, ALP00290
     3                69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84, ALP00300
     4                85,86,87,88,89,90,94,97,98,99,100,101/           ALP00310
      INTEGER*4 LC/60/                                                  ALP00320
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                      ALP00330
200   FORMAT(' TRACE ',I3,' ALPH$   :  ',110A1)                         ALP00340
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                               ALP00350
C                                                                       ALP00360
C                                                                       ALP00370
C                                                                       ALP00380
         DO 35 I=1,LA                                                   ALP00390
            IF(A$(I).NE.QUOTE) GOTO 15                                  ALP00400
C           HAVE FOUND A QUOTE MARK--DISREGARD IF 1ST INSTR,ELSE QUIT   ALP00410
               IF(I.EQ.1) GOTO 35                                       ALP00420
                  GOTO 40                                               ALP00430
15          IZ=FIND$(A$(I),LA,C$,LC,LOC)                                ALP00440
            IF(IZ.NE.0)GOTO 20                                          ALP00450
               WRITE(6,207)M1                                           ALP00460
207            FORMAT(' ***** INVALID CHARACTER    *****',5X,I5)       ALP00470
               A$(I)=BLNK                                               ALP00480
```

```
                IZ=1                                                                ALP00490
20              M(M1)=C2(IZ)                                                        ALP00500
                IF(IPRT.GE.10)WRITE(6,208)M1,C$(IZ),C2(IZ),M(M1)                    ALP00510
208             FORMAT(' ALPH$',I5,' ALPHA CHARACTER       ',3X,A1,3X,I3,          ALP00520
     2                                                        T75,I3)               ALP00530
                M1=M1+1                                                             ALP00540
35          CONTINUE                                                                ALP00550
C                                                                                   ALP00560
C                                                                                   ALP00570
40      ALPH$=0                                                                     ALP00580
        RETURN                                                                      ALP00590
C                                                                                   ALP00600
C       ERROR HANDLING SECTION FOLLOWS                                              ALP00610
C                                                                                   ALP00620
6000    WRITE(6,6001) FUNC$                                                         ALP00630
6001    FORMAT(' *** STRING LENGTH ERROR *** ',A4)                                  ALP00640
        WRITE(6,6010) LA,LB,IDIM                                                    ALP00650
6010    FORMAT(' LA=',I10,'     LB=',I10,'     IDIM=',I10)                          ALP00660
        ALPH$=-1                                                                    ALP00670
        RETURN                                                                      ALP00680
        END                                                                         ALP00690
```

```
      INTEGER FUNCTION ALP1$(A$,LA,M,M1)                                ALP00010
C*****************************************************************ALP00020
C**                                                                 **ALP00030
C**    STRING A$  BEGINS WITH A QUOTE AND HENCE IS AN ALPHA ENTRY   **ALP00040
C**    INSTRUCTION.  THIS ROUTINE COMPILES SUCH INSTRUCTIONS.       **ALP00050
C**                                                                 **ALP00060
C**                                                                 **ALP00070
C**    THE RETURN VALUE OF THE FUNCTION ALP1$ IS SET AS FOLLOWS:    **ALP00080
C**          0  =  CONTINUE TO COMPILE                              **ALP00090
C**         -1  =  AN ERROR IN COMPILING THE INSTRUCTION.           **ALP00100
C**                                                                 **ALP00110
C**                                                                 **ALP00120
C*****************************************************************ALP00130
      IMPLICIT INTEGER(A-Z)                                         ALP00140
      COMMON/TEXT/IDIM,IPRT                                         ALP00150
      COMMON/FLAGS/DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2 ALP00160
      COMMON/CNTR/P1,P2,P3,P4,P5,P6,P7,P8,P9,S1,S2                  ALP00170
      LOGICAL DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2      ALP00180
      INTEGER*4 P1,P2,P3,P4,P5,P6,P7,P8,P9,S1,S2                    ALP00190
      INTEGER*2 A$(IDIM)                                            ALP00200
C     INTEGER*2 BLNK/' '/                                           ALP00210
      INTEGER*2 QUOTE/'"'/,APPEND/'¬'/                              ALP00220
      INTEGER*4 FUNC$/'ALP1'/                                       ALP00230
      INTEGER*4 M(1)                                                ALP00240
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                  ALP00250
200   FORMAT(' TRACE ',I3,' ALP1$   : ',110A1)                      ALP00260
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                           ALP00270
C                                                                   ALP00280
CC                                                                  ALP00290
CC                                                                  ALP00300
C     STRIP OFF THE LEADING QUOTE                                   ALP00310
C                                                                   ALP00320
      IF(LCUT$(A$,LA,1)) 6015,6015,10                               ALP00330
C                                                                   ALP00340
CC                                                                  ALP00350
CC                                                                  ALP00360
C     STRIP OFF THE TRAILING QUOTE,IF ANY                           ALP00370
C                                                                   ALP00380
10    IF(A$(LA).EQ.QUOTE)LA=LA-1                                    ALP00390
C                                                                   ALP00400
CC                                                                  ALP00410
CC                                                                  ALP00420
C     SET THE LENGTH OF THE INSTRUCTION                             ALP00430
C                                                                   ALP00440
      IF(LA.LT.15)GOTO 15                                           ALP00450
      WRITE(6,204)                                                  ALP00460
204   FORMAT(' ***** ALPHA STRING TOO LONG *****')                  ALP00470
      LA=15                                                         ALP00480
```

```
15        IBYTE=LA+1                                                    ALP00490
          M(M1)=IBYTE                                                   ALP00500
          IF(IPRT.GE.20)WRITE(6,215)M1,IBYTE                            ALP00510
215       FORMAT(' ALP1$',I5,' LENGTH OF THIS INSTR IS',I3)             ALP00520
          M1=M1+1                                                       ALP00530
C                                                                       ALP00540
CC                                                                      ALP00550
CCC                                                                     ALP00560
C       ENCODE THE TEXT LENGTH INSTRUCTION                              ALP00570
C                                                                       ALP00580
          M(M1)=240+LA                                                  ALP00590
          IF(IPRT.GE.10)WRITE(6,211)M1,M(M1)                            ALP00600
211       FORMAT(' ALP1$',I5,' TEXT LENGTH INSTR',T75,I3)               ALP00610
          M1=M1+1                                                       ALP00620
C                                                                       ALP00630
CC                                                                      ALP00640
CCC                                                                     ALP00650
C       CHECK FOR ALPHA APPEND INSTRUCTION                              ALP00660
C                                                                       ALP00670
          IF(A$(1).NE.APPEND) GOTO 50                                   ALP00680
C                                                                       ALP00690
C              HAVE IDENTIFIED AN ALPHA APPEND INSTRUCTION              ALP00700
               M(M1)=127                                                ALP00710
               IF(IPRT.GE.10)WRITE(6,214)M1,M(M1)                       ALP00720
214            FORMAT(' ALP1$',I5,' ALPHA APPEND CHAR',T75,I3)          ALP00730
               M1=M1+1                                                  ALP00740
               IF(LCUT$(A$,LA,1)) 6015,6015,50                          ALP00750
C                                                                       ALP00760
CC                                                                      ALP00770
CCC                                                                     ALP00780
C       ENCODE TEXTUAL STRING                                           ALP00790
C                                                                       ALP00800
50        ALP1$=ALPH$(A$,LA,M,M1)                                       ALP00810
          RETURN                                                        ALP00820
C                                                                       ALP00830
C       ERROR HANDLING SECTION FOLLOWS                                  ALP00840
C                                                                       ALP00850
6000    WRITE(6,6001) FUNC$                                             ALP00860
6001    FORMAT(' *** STRING LENGTH ERROR *** ',A4)                      ALP00870
        WRITE(6,6010) LA,LB,IDIM                                        ALP00880
6010    FORMAT(' LA=',I10,'     LB=',I10,'     IDIM=',I10)              ALP00890
        ALP1$=-1                                                        ALP00900
        RETURN                                                          ALP00910
6015    WRITE(6,6016)                                                   ALP00920
6016    FORMAT(' ***** INVALID OPERAND IN ALPHA ENTRY INSTR *****')     ALP00930
        ALP1$=-1                                                        ALP00940
        RETURN                                                          ALP00950
        END                                                             ALP00960
```

```
      INTEGER FUNCTION ASGN$(A$,LA,B$,LB)                                ASG00010
C*****************************************************************     *ASG00020
C**                                                                   **ASG00030
C**     THIS FUNCTION  IS A STRING ASSIGNMENT OPERATOR.  THE STRING   **ASG00040
C**     IN A$ IS COPIED INTO B$.   THE NULL STRING LA=0 IS A VALID    **ASG00050
C**     STRING AND WILL BE COPIED CORRECTLY.                          **ASG00060
C**                                                                   **ASG00070
C**                                                                   **ASG00080
C*****************************************************************     *ASG00090
      COMMON/TEXT/IDIM,IPRT                                              ASG00100
      INTEGER*2 A$(IDIM),B$(IDIM)                                        ASG00110
      INTEGER*4 FUNC$/'ASGN'/                                            ASG00120
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                       ASG00130
200   FORMAT(' TRACE ',I3,' ASGN$   :  ',110A1)                          ASG00140
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                                ASG00150
C                                                                        ASG00160
C                                                                        ASG00170
C                                                                        ASG00180
      IF(LA.EQ.0) GOTO 20                                                ASG00190
10    DO 15 I=1,LA                                                       ASG00200
         B$(I)=A$(I)                                                     ASG00210
15    CONTINUE                                                           ASG00220
20    LB=LA                                                              ASG00230
      ASGN$=1                                                            ASG00240
      RETURN                                                             ASG00250
C                                                                        ASG00260
C     ERROR HANDLING SECTION FOLLOWS                                     ASG00270
C                                                                        ASG00280
6000  WRITE(6,6001) FUNC$                                                ASG00290
6001  FORMAT(' *** STRING LENGTH ERROR *** ',A4)                         ASG00300
      WRITE(6,6010) LA,LB,IDIM                                           ASG00310
6010  FORMAT(' LA=',I10,'     LB=',I10,'     IDIM=',I10)                 ASG00320
      ASGN$=0                                                            ASG00330
      RETURN                                                             ASG00340
      END                                                                ASG00350
```

```
      INTEGER FUNCTION BSTR$(M,M1,TOTAL,TITLE$)                          BST00010
C*****************************************************************     *BST00020
C**                                                                   **BST00030
C**    THIS FUNCTION TAKES AN ARRAY (M) OF MACHINE CODE (DECIMAL)     **BST00040
C**    INSTRUCTIONS AND CONVERTS THEM INTO AN ARRAY (W) OF BINARY     **BST00050
C**    INSTRUCTIONS.  IT ALSO COMPUTES THE BARCODE CHECKSUM, AND      **BST00060
C**    SEGMENTS THE ARRAY INTO BARCODE LINES.                         **BST00070
C**                                                                   **BST00080
C**                                                                   **BST00090
C**    THE RETURN VALUE OF THE FUNCTION BSTR$ IS SET AS FOLLOWS:      **BST00100
C**          0  =  CONTINUE TO COMPILE                                **BST00110
C**         -1  =  AN ERROR IN COMPILING THE INSTRUCTION.             **BST00120
C**                                                                   **BST00130
C**                                                                   **BST00140
C*****************************************************************     BST00150
      IMPLICIT INTEGER(A-Z)                                              BST00160
      COMMON/TEXT/IDIM,IPRT                                              BST00170
      INTEGER*2 W(133),TITLE$(133)                                       BST00180
      INTEGER*2 ALPHA(133),BLNK/' '/,ZERO/'0'/,ONE/'1'/                  BST00190
      INTEGER*4 FUNC$/'BSTR'/                                            BST00200
      INTEGER*4 M(1),M1,W1                                               BST00210
      IF(IPRT.GE.10) WRITE(6,200)                                        BST00220
200   FORMAT(' TRACE ',I3,' BSTR$   :  ',)                               BST00230
C                                                                        BST00240
C                                                                        BST00250
C                                                                        BST00260
C     INITIALIZE COUNTERS                                                BST00270
C                                                                        BST00280
         CHECK=0                                                         BST00290
         TOTAL=0                                                         BST00300
         SEQNUM=0                                                        BST00310
         LEAD=0                                                          BST00320
         ROW=0                                                           BST00330
         P=1                                                             BST00340
         W1=27                                                           BST00350
C                                                                        BST00360
C                                                                        BST00370
C                                                                        BST00380
C     WRITE THE TITLE TO THE BINARY CODE ARRAY                           BST00390
C                                                                        BST00400
         WRITE(4,776)(TITLE$(JJ),JJ=26,IDIM)                            BST00410
776      FORMAT(80A1)                                                    BST00420
C                                                                        BST00430
C                                                                        BST00440
C                                                                        BST00450
C     CHECK FOR END OF PROGRAM                                           BST00460
C                                                                        BST00470
320      IF(M(P).LE.-99) GOTO 530                                        BST00480
```

```
C                                                                       BST00490
CCCC                                                                    BST00500
CCCC                                                                    BST00510
CCCC    EXTRACT NUMBER OF BYTES IN  INSTRUCTION                         BST00520
C                                                                       BST00530
        IBYTE=M(P)                                                      BST00540
        NBYTE=IBYTE                                                     BST00550
        P=P+1                                                           BST00560
C                                                                       BST00570
CCCC                                                                    BST00580
CCCC                                                                    BST00590
CCCC    EXTRACT NEXT OPERAND OF THE INSTRUCTION                         BST00600
C                                                                       BST00610
390     OPERND=M(P)                                                     BST00620
        P=P+1                                                           BST00630
C                                                                       BST00640
CCCC                                                                    BST00650
CCCC                                                                    BST00660
CCCC    CONVERT OPERAND    TO BINARY AND LOAD INTO ARRAY W              BST00670
C                                                                       BST00680
        CHECK=CHECK+OPERND                                              BST00690
        IF(CHECK.GT.255) CHECK=CHECK-255                                BST00700
        IF(IPRT.GE.10) WRITE(6,555)ROW,OPERND,CHECK                     BST00710
555     FORMAT(' SEND TO AIN$ ROW:',I3,'  OPERAND:',I6,'  CHECKSUM=',I5) BST00720
        IF(AIN$(OPERND,W(W1)))  6000,420,420                            BST00730
C                                                                       BST00740
CCCC                                                                    BST00750
CCCC                                                                    BST00760
CCCC    IF SUCCESSFUL CONVERSION, DECREASE BYTES REMAINING              BST00770
CCCC    INCREMENT THE ROW COUNT, AND CHECK TO SEE IF END OF BARCODE ROW BST00780
C                                                                       BST00790
420     IBYTE=IBYTE-1                                                   BST00800
        W1=W1+8                                                         BST00810
        ROW=ROW+1                                                       BST00820
        IF(ROW.EQ.13) GOTO 530                                          BST00830
C                                                                       BST00840
CCCC                                                                    BST00850
CCCC                                                                    BST00860
CCCC    CHECK TO SEE IF INSTRUCTION HAS BEEN COMPLETELY ENCODED         BST00870
C                                                                       BST00880
480     IF(IBYTE.EQ.0) GOTO 320                                         BST00890
        GOTO 390                                                        BST00900
C                                                                       BST00910
CCCC                                                                    BST00920
CCCC                                                                    BST00930
CCCC    PROCESS END OF BARCODE ROW, FIRST SAVE ENDING LOCATION IN TEMP  BST00940
C       BARCODE ROW (THIS LOCATION WILL BE DIFFERENT DEPENDING ON       BST00950
C       WHETHER YOU ENTER ROUTINE BY DETECTING END OF ROW OR BY END OF  BST00960
```

```
C       PROGRAM. THEN CHECK FOR CONTINUATION OF INSTRUCTION THAT MUST      BST00970
C       CROSS BARCODE BOUNDARIES.                                          BST00980
C                                                                          BST00990
530        WP=W1                                                           BST01000
           IF(IBYTE.NE.0) GOTO 560                                         BST01010
                TRAIL=0                                                    BST01020
                GOTO 580                                                   BST01030
C                                                                          BST01040
CCC                                                                        BST01050
CCC                                                                        BST01060
C       CALCULATE NUMBER OF TRAILING BYTES IN BARCODE ROW                  BST01070
C                                                                          BST01080
560        TRAIL=NBYTE-IBYTE                                               BST01090
C                                                                          BST01100
CCC                                                                        BST01110
CCC                                                                        BST01120
CCC     COMPUTE THIRD BYTE OF BARCODE ROW AND CONVERT TO BINARY            BST01130
CCC                                                                        BST01140
CCC     SINCE THE HP-41C INSTRUCTIONS ARE OF VARYING LENGTH, THEY WILL     BST01150
CCC     MOST COMMONLY STRADDLE THE BORDER BETWEEN TWO ROWS OF BAR CODE.    BST01160
CCC     THE THIRD BYTE OF A BAR-CODE ROW CONTAINS, IN THE 4 HIGH ORDER     BST01170
CCC     BITS, THE NUMBER OF LEADING BYTES AND IN THE 4 LOW ORDER BITS      BST01180
CCC     THE NUMBER OF TRAILING BYTES.                                      BST01190
C                                                                          BST01200
580        THIRD=(16*LEAD)+TRAIL                                           BST01210
           W1=19                                                           BST01220
           CHECK=CHECK+THIRD                                               BST01230
           IF(CHECK.GT.255) CHECK=CHECK-255                                BST01240
           IF(IPRT.GE.10) WRITE(6,555)ROW,THIRD,CHECK                      BST01250
           IF(AIN$(THIRD,W(W1)))  6000,1090,1090                           BST01260
C                                                                          BST01270
CCC                                                                        BST01280
CCC                                                                        BST01290
CCC     COMPUTE SECOND BYTE OF BARCODE ROW AND CONVERT TO BINARY           BST01300
CCC                                                                        BST01310
CCC     THE SECOND BYTE IS SPLIT INTO TWO PARTS.  THE 4 HIGH ORDER BITS    BST01320
CCC     CONTAIN THE PROGRAM TYPE (1=NONPRIVATE AND 2=PRIVATE), AND THE     BST01330
CCC     4 LOW ORDER BITS CONTAIN THE SEQUENCE NUMBER, WHICH IS THE BAR-    BST01340
CCC     CODE ROW NUMBER MINUS 1, MODULO 16.                                BST01350
C                                                                          BST01360
1090       SECND=16*MOD(SEQNUM,16)                                         BST01370
           SEQNUM=SEQNUM+1                                                 BST01380
           W1=11                                                           BST01390
           CHECK=CHECK+SECND                                               BST01400
           IF(CHECK.GT.255) CHECK=CHECK-255                                BST01410
           IF(IPRT.GE.10) WRITE(6,555)ROW,SECND,CHECK                      BST01420
           IF(AIN$(SECND,W(W1)))  6000,1180,1180                           BST01430
C                                                                          BST01440
```

```
C                                                                       BST01450
C                                                                       BST01460
C      COMPUTE FIRST  BYTE OF BARCODE RCW AND CONVERT TO BINARY         BST01470
C                                                                       BST01480
C      THE FIRST  BYTE CONTAINS THE CHECKSUM.  THIS BYTE IS A PARITY    BST01490
C      CHECK IN THE FORM OF A RUNNING SUMMATION, MODULO 256 WITH A WRAP- BST01500
C      AROUND CARRY (0,1,2,...255,256,1,2,...).                         BST01510
C                                                                       BST01520
C                                                                       BST01530
1180      W1=3                                                          BST01540
          FIRST=CHECK                                                   BST01550
          IF(IPRT.GE.10) WRITE(6,555)ROW,FIRST,CHECK                    BST01560
          IF(AIN$(FIRST,W(W1)))  6000,1220,1220                         BST01570
C                                                                       BST01580
C                                                                       BST01590
C                                                                       BST01600
C      ADD THE START AND STOP BITS AND ADD AN END OF ROW FLAG           BST01610
C                                                                       BST01620
1220      IF(IPRT.GE.20) WRITE(6,556)                                   BST01630
556       FORMAT(' END OF BARCODE ROW**********')                       BST01640
          W(1)=0                                                        BST01650
          W(2)=0                                                        BST01660
          W(WP)=1                                                       BST01670
          ENDING=WP+1                                                   BST01680
          W(ENDING)=0                                                   BST01690
          ENDBIT=WP+2                                                   BST01700
          W(ENDBIT)=-99                                                 BST01710
C                                                                       BST01720
C                                                                       BST01730
C                                                                       BST01740
C      TRANSFER THE COMPLETED BARCODE ROW EITHER DIRECTLY TO THE         BST01750
C      PLOTTER, OR TO A AN ARRAY OF INTEGER*2 VARIABLES WHICH HOLD      BST01760
C      ZERO'S OR ONE'S                                                  BST01770
C                                                                       BST01780
C***********************************************************************BST01790
C                                                                       BST01800
C        INSERT CALL TO VERSATEC HERE.                                  BST01810
C                                                                       BST01820
C***********************************************************************BST01830
C                                                                       BST01840
C                                                                       BST01850
          IF(IPRT.GE.20) WRITE(6,558) B1,ENDBIT                         BST01860
558       FORMAT(' TRANSFER TO BINARY ARRAY AT',I7,' NUMBER DIGITS',I5) BST01870
          DO 1350 I=1,ENDING                                            BST01880
               IF(W(I).EQ.1) GOTO 559                                   BST01890
                    ALPHA(I)=ZERO                                       BST01900
                    GOTO 1350                                           BST01910
559                 ALPHA(I)=ONE                                        BST01920
```

```
1350      CONTINUE                                                          BST01930
          IF(ENDING.EQ.132) GOTO 1736                                       BST01940
          DO 1735 I=ENDBIT,132                                              BST01950
             ALPHA(I)=BLNK                                                  BST01960
1735      CONTINUE                                                          BST01970
1736      WRITE(4,777) (ALPHA(I),I=1,132)                                   BST01980
777       FORMAT(66A1,/,5X,66A1)                                            BST01990
C                                                                           BST02000
C                                                                           BST02010
C                                                                           BST02020
C       IF REQUIRED, PRINT THE BARCODE RCW AS ZERO'S AND ONE'S ON PAPER     BST02030
C                                                                           BST02040
          IF(IPRT.GE.20)WRITE(6,201)(W(I),I=1,ENDING)                       BST02050
201       FORMAT(' ',132I1)                                                 BST02060
C                                                                           BST02070
C                                                                           BST02080
C                                                                           BST02090
C                                                                           BST02100
C                                                                           BST02110
C       SET NUMBER OF LEADING BYTES FOR NEXT ROW AND RE-INITIALIZE          BST02120
C                                                                           BST02130
          LEAD=IBYTE                                                        BST02140
          TOTAL=TOTAL+ROW                                                   BST02150
          ROW=0                                                             BST02160
          W1=27                                                             BST02170
          IF(M(P)) 1400,480,480                                             BST02180
C                                                                           BST02190
C                                                                           BST02200
C                                                                           BST02210
C       SET FINAL VALUES AND RETURN                                         BST02220
C                                                                           BST02230
1400      BSTR$=0                                                           BST02240
          M1=1                                                              BST02250
          RETURN                                                            BST02260
C                                                                           BST02270
C                                                                           BST02280
C                                                                           BST02290
C       ERROR HANDLING SECTION FOLLOWS                                      BST02300
C                                                                           BST02310
6000    WRITE(6,6001) FUNC$                                                 BST02320
6001    FORMAT(' ******  ERROR IN BARCODE PRODUCTION ****** ',A4)           BST02330
        PM1=P-1                                                             BST02340
        WRITE(6,6010) SEQNUM,PM1,M(PM1),CHECK                               BST02350
6010    FORMAT(' ROW=',I3,' M(',I4,')  OPERAND=',I3,' CHECKSUM=',I4)        BST02360
        BSTR$=-1                                                            BST02370
        RETURN                                                              BST02380
        END                                                                 BST02390
```

```
      INTEGER FUNCTION COMP$(A$,LA,M,M1)                                    COM00010
C*****************************************************************COM00020
C**                                                                 **COM00030
C**    THIS IS THE MASTER INSTRUCTION INTERPRETATION ROUTINE FOR THE **COM00040
C**    HP41C COMPILER.  THIS ROUTINE IS USED BY BOTH THE BAR CODE   **COM00050
C**    GENERATOR AND THE CALCULATOR EMULATOR.                       **COM00060
C**                                                                 **COM00070
C**    INSTRUCTIONS ARE PASSED TO THIS RCUTINE ONE AT A TIME IN     **COM00080
C**    A TEXT STRING A$.  THE ARRAY M IS THE TOTAL ARRAY OF DECIMAL **COM00090
C**    INTEGER KEY CODES (MACHINE INSTRUCTIONS), AND M1 IS THE      **COM00100
C**    POSITION WHERE  THE NEXT DECODED MACHINE INSTRUCTION WILL BE **COM00110
C**    PLACED.  THUS, THE INPUT TO THIS ROUTINE IS A TEXTUAL HP41C  **COM00120
C**    INSTRUCTION AND THE OUTPUT IS ONE OR MORE DECIMAL KEY CODES  **COM00130
C**    PLACED APPROPRIATELY INTO ARRAY M.                           **COM00140
C**                                                                 **COM00150
C**    THE RETURN VALUE OF THE FUNCTION COMP$ IS SET AS FOLLOWS:    **COM00160
C**          1 =   END STATEMENT FOUND, END COMPILATION.            **COM00170
C**          0  =  CONTINUE TO COMPILE                              **COM00180
C**         -1  =  AN ERROR IN COMPILING THE INSTRUCTION.           **COM00190
C**                                                                 **COM00200
C**                                                                 **COM00210
C**                                                                 **COM00220
C**                                                                 **COM00230
C*****************************************************************COM00240
      IMPLICIT INTEGER(A-Z)                                                 COM00250
      COMMON/TEXT/IDIM,IPRT                                                 COM00260
      COMMON/FLAGS/DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2         COM00270
      COMMON/CNTR/P1,P2,P3,P4,P5,P6,P7,P8,P9,S1,S2                          COM00280
      LOGICAL DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2              COM00290
      INTEGER*4 P1,P2,P3,P4,P5,P6,P7,P8,P9,S1,S2                            COM00300
      INTEGER*2 A$(IDIM)                                                    COM00310
      INTEGER*2 BLNK/' '/                                                   COM00320
      INTEGER*2 T1$(40),T2$(40),SAV$(40),WORK$(80)                          COM00330
      INTEGER*2 SS1$(40),SS2$(40),SS3$(40),SS4$(40),SS5$(40)                COM00340
      INTEGER*4 LT1,LT2,LSAV,LWORK                                          COM00350
      INTEGER*4 LSS1,LSS2,LSS3,LSS4,LSS5                                    COM00360
      INTEGER*4 M(1),M1                                                     COM00370
      INTEGER*4 FUNC$/'COMP'/                                               COM00380
      INTEGER*2 END(3)/'E','N','D'/,                                        COM00390
     1          RCL(3)/'R','C','L'/,                                        COM00400
     3          QUOTE/'"'/,                                                 COM00410
C    4          APPEND/'¬'/,                                                COM00420
     5          LBL(3)/'L','B','L'/,                                        COM00430
     6          GTO(3)/'G','T','O'/,                                        COM00440
     7          XEQ(3)/'X','E','Q'/,                                        COM00450
     8          XRO(3)/'X','R','O'/,                                        COM00460
     9          STO(3)/'S','T','O'/,P/'P'/,                                 COM00470
     *          IND(3)/'I','N','D'/                                         COM00480
```

```
C     2          END2(5)/'.','E','N','D','.'/,                                  COM00490
C     2          AQUOTE(2)/'A',''''/,                                           COM00500
C     2          MINUS/'-'/,                                                    COM00510
      INTEGER*4 MRCL(5)/144,32,'R','C','L'/,MSTO(5)/145,48,'S','T','O'/         COM00520
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                              COM00530
200   FORMAT(' TRACE ',I3,' COMP$    :  ',110A1)                                COM00540
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                                       COM00550
C                                                                               COM00560
CC                                                                              COM00570
C     SET FLAGS AND INITIALIZE COUNTERS                                         COM00580
C                                                                               COM00590
      INDIR=.FALSE.                                                             COM00600
C                                                                               COM00610
CC                                                                              COM00620
CC                                                                              COM00630
C     CHECK FOR NULL STRING ENTRY INTO COMP$                                    COM00640
C                                                                               COM00650
5     IF(LA.NE.0) GOTO 10                                                       COM00660
            COMP$=0                                                             COM00670
            RETURN                                                              COM00680
C                                                                               COM00690
CC                                                                              COM00700
CC                                                                              COM00710
C     CHECK FOR CATEGORY THREE SPECIAL INSTRUCTIONS                             COM00720
C                                                                               COM00730
10    IF(EQ$(A$,LA,RCL,3,3)) 6000,15,11                                         COM00740
11          COMP$=MEM$(A$,LA,M,M1,MRCL)                                         COM00750
            PDIGIT=.FALSE.                                                      COM00760
            RETURN                                                              COM00770
C                                                                               COM00780
15    IF(EQ$(A$,LA,STO,3,3)) 6000,20,16                                         COM00790
C           MAKE A QUICK CHECK FOR THE STOP INSTRUCTION                         COM00800
16          IF(A$(4).EQ.P) GOTO 65                                              COM00810
            COMP$=MEM$(A$,LA,M,M1,MSTO)                                         COM00820
            PDIGIT=.FALSE.                                                      COM00830
            RETURN                                                              COM00840
C                                                                               COM00850
20    IF(EQ$(A$,LA,LBL,3,3)) 6000,25,21                                         COM00860
21          COMP$=LBL$(A$,LA,M,M1)                                              COM00870
            PDIGIT=.FALSE.                                                      COM00880
            RETURN                                                              COM00890
C                                                                               COM00900
25    IF(EQ$(A$,LA,GTO,3,3)) 6000,30,26                                         COM00910
26          COMP$=GTO$(A$,LA,M,M1)                                              COM00920
            PDIGIT=.FALSE.                                                      COM00930
            RETURN                                                              COM00940
C                                                                               COM00950
30    IF(EQ$(A$,LA,XEQ,3,3)) 6000,35,31                                         COM00960
```

```
31              COMP$=XEQ$(A$,LA,M,M1)                                  COM00970
                PDIGIT=.FALSE.                                          COM00980
                RETURN                                                  COM00990
C                                                                       COM01000
35      IF(EQ$(A$,LA,XRO,3,3)) 6000,40,36                               COM01010
36              COMP$=XRO$(A$,LA,M,M1)                                  COM01020
                PDIGIT=.FALSE.                                          COM01030
                RETURN                                                  COM01040
C                                                                       COM01050
40      IF(EQ$(A$,LA,END,3,3)) 6000,45,41                               COM01060
41              COMP$=END$(A$,LA,M,M1)                                  COM01070
                PDIGIT=.FALSE.                                          COM01080
                RETURN                                                  COM01090
C                                                                       COM01100
CC                                                                      COM01110
CC                                                                      COM01120
C       CHECK FOR ALPHABETIC ENTRY INSTRUCTION.                         COM01130
C                                                                       COM01140
45      IF(A$(1).NE.QUOTE) GOTO 50                                      COM01150
46              COMP$=ALPI$(A$,LA,M,M1)                                 COM01160
                PDIGIT=.FALSE.                                          COM01170
                RETURN                                                  COM01180
C                                                                       COM01190
CC                                                                      COM01200
CC                                                                      COM01210
C       CHECK FOR NUMERIC ENTRY INSTRUCTION.                            COM01220
C                                                                       COM01230
50      IF(NUMC$(A$,LA,IANSW))6000,55,51                                COM01240
51              COMP$=DIGT$(A$,LA,M,M1)                                 COM01250
                PDIGIT=.TRUE.                                           COM01260
                RETURN                                                  COM01270
C                                                                       COM01280
CC                                                                      COM01290
CC                                                                      COM01300
C       CHECK FOR CATEGORY ONE INSTR(ONE BYTE) BY LOOKING FOR BLANK     COM01310
C                                                                       COM01320
55      P1=POS$(A$,LA,BLNK,1,1)                                         COM01330
        IF(P1) 6000,65,70                                               COM01340
C                                                                       COM01350
CC                                                                      COM01360
CC                                                                      COM01370
C       NO BLANK IN STRING IMPLIES HAVE FOUND ONE BYTE INSTRUCTION      COM01380
C                                                                       COM01390
65          COMP$=IONE$(A$,LA,M,M1,1)                                   COM01400
            PDIGIT=.FALSE.                                              COM01410
            RETURN                                                      COM01420
C                                                                       COM01430
C                                                                       COM01440
```

```
C                                                                       COM01450
CCC     BLANK IN STRING MEANS MULTI-WORD INSTRUCTION, NOW EXTRACT PREFIX COM01460
CCC                                                                     COM01470
70        IF(PARS$(A$,LA,SS1$,LSS1)) 6000,65,75                         COM01480
CCCCC                                                                   COM01490
CCCCC                                                                   COM01500
CCCCC                                                                   COM01510
CCCCC   CHECK FOR INDIRECT ADDRESSING                                   COM01520
CCCCC                                                                   COM01530
75      P6=POS$(A$,LA,IND,3,1)                                          COM01540
        IF(P6) 6000,80,76                                               COM01550
76              INDIR=.TRUE.                                            COM01560
                IF(IPRT.GE.20)WRITE(6,235)                              COM01570
235             FORMAT(' DETECTED INDIRECT GOTO INSTRUCTION')           COM01580
                IF(LCUT$(A$,LA,3)) 6000,6080,80                         COM01590
C                                                                       COM01600
CCCCC                                                                   COM01610
CCCCC                                                                   COM01620
CCCCC   COMPILE THE PREFIX OF A MULTI-WORD INSTRUCTION                  COM01630
CCCCC                                                                   COM01640
80        COMP$=IONE$(SS1$,LSS1,M,M1,2)                                 COM01650
C                                                                       COM01660
CCCCC                                                                   COM01670
CCCCC                                                                   COM01680
CCCCC   EXTRACT THE POSTFIX OF A MULTI-WORD INSTRUCTION                 COM01690
CCCCC                                                                   COM01700
85        IF(PARS$(A$,LA,SS2$,LSS2)) 6000,90,6090                       COM01710
CC                                                                      COM01720
CCCCC                                                                   COM01730
CCCCC                                                                   COM01740
CCCCC                                                                   COM01750
CCCCC   COMPILE THE POSTFIX OF A MULTI-WORD INSTRUCTION                 COM01760
CCCCC                                                                   COM01770
90        COMP$=MIN0(COMP$,ITWO$(SS2$,LSS2,M,M1,INDIR))                 COM01780
          PDIGIT=.FALSE.                                                COM01790
          RETURN                                                        COM01800
C                                                                       COM01810
CCCCC                                                                   COM01820
CCCCC                                                                   COM01830
CCCCC   ERROR HANDLING SECTION FOLLOWS                                  COM01840
C                                                                       COM01850
6000    WRITE(6,6001) FUNC$                                             COM01860
6001    FORMAT(' *** STRING LENGTH ERROR *** ',A4)                      COM01870
        COMP$=-1                                                        COM01880
        RETURN                                                          COM01890
6080    WRITE(6,6081)                                                   COM01900
6081    FORMAT(' ***** ERROR                *****')                     COM01910
        CCMP$=-1                                                        COM01920
```

```
      RETURN                                                            COM01930
6090  WRITE(6,6091)                                                     COM01940
6091  FORMAT(' ***** ERROR                    *****')                  COM01950
      COMP$=-1                                                          COM01960
      RETURN                                                            COM01970
      END                                                               COM01980
```

```
      INTEGER FUNCTION CON$(A$,LA,B$,LB,C$,LC)                          CON00010
C*****************************************************************    *CON00020
C**                                                                   **CON00030
C**    STRING A$ AND STRING B$ ARE CONCATENATED AND PLACED IN C$.     **CON00040
C**                                                                   **CON00050
C**    IT IS FEASIBLE TO CON$(A$,LA,B$,LB,A$,LA)  OR                  **CON00060
C**                      CON$(A$,LA,B$,LB,B$,LB)                      **CON00070
C**    IN WHICH CASE THE APPROPRIATE STRING WILL BE REPLACED.         **CON00080
C**                                                                   **CON00090
C**                                                                   **CON00100
C**    THE NUMBER OF CHARACTERS IN THE RESULTING STRING C$ IS RETURNED**CON00110
C**    AS THE VALUE OF THE FUNCTION CON$, UNLESS THERE IS A LOSS OF   **CON00120
C**    CHARACTERS IN WHICH CASE THE NUMBER OF LOST CHARACTERS IS      **CON00130
C**    RETURNED AS A NEGATIVE NUMBER.                                 **CON00140
C**                                                                   **CON00150
C*****************************************************************    *CON00160
      IMPLICIT INTEGER(A-Z)                                             CON00170
      COMMON/TEXT/IDIM,IPRT                                             CON00180
      INTEGER*2 A$(IDIM),B$(IDIM),C$(IDIM)                              CON00190
      INTEGER*4 FUNC$/'CON'/                                            CON00200
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                      CON00210
      IF(IPRT.GE.10) WRITE(6,201)LB,(B$(I),I=1,LB)                      CON00220
200   FORMAT(' TRACE ',I3,' CON$    :  ',110A1)                         CON00230
201   FORMAT('     AND',I3,' B$     :  ',110A1)                         CON00240
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                               CON00250
      IF(LB.GT.IDIM.OR.LB.LT.0) GOTO 6000                               CON00260
C                                                                       CON00270
CC                                                                      CON00280
C                                                                       CON00290
      LOSS=0                                                            CON00300
C                                                                       CON00310
CC                                                                      CON00320
CC    DETERMINE LENGTH OF RESULT                                        CON00330
C                                                                       CON00340
      ILC=LA+LB                                                         CON00350
      IF(ILC.LE.IDIM) GOTO 20                                           CON00360
         LOSS=ILC-IDIM                                                  CON00370
         ILB=LB-LOSS                                                    CON00380
         ILC=IDIM                                                       CON00390
         IF(IPRT.GE.05) WRITE(6,202) LOSS                               CON00400
202      FORMAT(' LOSS OF',I3,' CHARACTERS DURING CONCATENATION')       CON00410
         GOTO 25                                                        CON00420
20    ILB=LB                                                            CON00430
25    ILA=LA                                                            CON00440
      INDEX=ILC                                                         CON00450
C                                                                       CON00460
CC                                                                      CON00470
C                                                                       CON00480
```

```
C       MOVE B$ INTO C$                                                  CON00490
C                                                                        CON00500
        IF(ILB.LE.0) GOTO 40                                             CON00510
        IND=ILB                                                          CON00520
        DO 35 I=1,ILB                                                    CON00530
           C$(INDEX)=B$(IND)                                             CON00540
           IF(IPRT.GE.30)WRITE(6,207) IND,B$(IND),INDEX,C$(INDEX)        CON00550
207        FORMAT(' MOVE B(',I3,')=',A1,'  IS NOW C(',I3,')=',A1)        CON00560
           IND=IND-1                                                     CON00570
           INDEX=INDEX-1                                                 CON00580
35      CONTINUE                                                         CON00590
C                                                                        CON00600
C                                                                        CON00610
C                                                                        CON00620
C       MOVE A$ INTO C$                                                  CON00630
C                                                                        CON00640
40      IF(ILA.LE.0) GOTO 60                                             CON00650
        IND=ILA                                                          CON00660
        DO 45 I=1,ILA                                                    CON00670
           C$(INDEX)=A$(IND)                                             CON00680
           IF(IPRT.GE.30)WRITE(6,209) IND,A$(IND),INDEX,C$(INDEX)        CON00690
209        FORMAT(' MOVE A(',I3,')=',A1,'  IS NOW C(',I3,')=',A1)        CON00700
           IND=IND-1                                                     CON00710
           INDEX=INDEX-1                                                 CON00720
45      CONTINUE                                                         CON00730
C                                                                        CON00740
C                                                                        CON00750
C                                                                        CON00760
C       SET LENGTH OF C$ AND ASSIGN VALUE OF CONS$ AND RETURN.           CON00770
C                                                                        CON00780
60      LC=ILC                                                           CON00790
65      IF(IPRT.GE.20) WRITE(6,203)LC,(C$(I),I=1,LC)                     CON00800
203     FORMAT(' CONCAT:  LC=',I3,' "',110A1)                            CON00810
        IF(LOSS.NE.0) GOTO 70                                            CON00820
           CON$=ILC                                                      CON00830
           GOTO 75                                                       CON00840
70      CON$=-LOSS                                                       CON00850
75      RETURN                                                           CON00860
C                                                                        CON00870
C                                                                        CON00880
C       ERROR HANDLING SECTION FOLLOWS                                   CON00890
C                                                                        CON00900
6000    WRITE(6,6001) FUNC$                                              CON00910
6001    FORMAT(' *** STRING LENGTH ERROR *** ',A4)                       CON00920
        CON$=-1                                                          CON00930
        RETURN                                                           CON00940
        END                                                              CON00950
```

```
      INTEGER FUNCTION DIGT$(A$,LA,M,M1)                                DIG00010
C*****************************************************************DIG00020
C**                                                                 **DIG00030
C**   THIS IS A FUNCTION THAT IS PART OF THE HP41C COMPILER.  IT IS  **DIG00040
C**   CALLED WHEN A DIGIT ENTRY INSTRUCTION IS ENCOUNTERED.         **DIG00050
C**                                                                 **DIG00060
C**                                                                 **DIG00070
C**    THE RETURN VALUE OF THE FUNCTION DIGT$ IS SET AS FOLLOWS:    **DIG00080
C**          0  =  CONTINUE TO COMPILE                              **DIG00090
C**         -1  =  AN ERROR IN COMPILING THE INSTRUCTION.           **DIG00100
C**                                                                 **DIG00110
C**                                                                 **DIG00120
C*****************************************************************DIG00130
      IMPLICIT INTEGER(A-Z)                                         DIG00140
      COMMON/TEXT/IDIM,IPRT                                         DIG00150
      COMMON/FLAGS/DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2 DIG00160
      LOGICAL DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2      DIG00170
      INTEGER*2 A$(IDIM)                                            DIG00180
      INTEGER*2 PLUS/'+'/                                           DIG00190
      INTEGER*2 C$(13)/'0','1','2','3','4','5','6','7','8','9','.',DIG00200
     2                'E','-'/                                     DIG00210
      INTEGER*4 LC/13/                                              DIG00220
      INTEGER*4 FUNC$/'DIGT'/                                       DIG00230
      INTEGER*4 M(1)                                                DIG00240
      LOGICAL PDECIM,CHSFLG                                         DIG00250
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                  DIG00260
200   FORMAT(' TRACE ',I3,' DIGT$   : ',11(0A1))                    DIG00270
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                           DIG00280
C                                                                   DIG00290
C                                                                   DIG00300
C                                                                   DIG00310
C     ADD A NULL INSTRUCTION BETWEEN ADJACENT DIGIT ENTRY INSTR.    DIG00320
C                                                                   DIG00330
      IF(.NOT.PDIGIT)GOTO 400                                       DIG00340
C        ADJACENT DIGIT ENTRY INSTRUCTION FOUND                     DIG00350
         IBYTE=1                                                    DIG00360
         M(M1)=IBYTE                                                DIG00370
         IF(IPRT.GE.20)WRITE(6,212)M1,IBYTE                         DIG00380
212      FORMAT(' DIGT$',I5,' LENGTH OF THIS INSTR IS',I3)          DIG00390
         M1=M1+1                                                    DIG00400
         M(M1)=0                                                    DIG00410
         IF(IPRT.GE.20)WRITE(6,213)M1,M(M1)                         DIG00420
213      FORMAT(' DIGT$',I5,' NULL INSTR FOR PRECEEDING DIGIT ENTRY',DIG00430
     2                                                  T75,I3)     DIG00440
         M1=M1+1                                                    DIG00450
C                                                                   DIG00460
C                                                                   DIG00470
C                                                                   DIG00480
```

```
C                                                                       DIG00490
CC      CHECK FOR DIGIT ENTRY INSTRUCTION PRECEEDED BY PLUS SIGN.       DIG00500
C                                                                       DIG00510
400     IF(A$(1).NE.PLUS)GOTO 450                                       DIG00520
C                                                                       DIG00530
CC         NOTE THAT YOU GO AROUND THE FOLLOWING LINE  IF THE FIRST     DIG00540
CC         DIGIT IS NOT A PLUS SIGN OR IF THE PLUS SIGN IS ALL ALONE.   DIG00550
CC         A PLUS SIGN BY ITSELF INDICATES ADDITION NOT A DIGIT         DIG00560
CC         ENTRY INSTRUCTION.  ADDITION IS COMPILED BY A TABLE LOOKUP.  DIG00570
C                                                                       DIG00580
CC            CALL LCUT$(A$,LA,1)                                       DIG00590
CC                                                                      DIG00600
CC                                                                      DIG00610
CC                                                                      DIG00620
CC      SET THE LENGTH OF THE INSTRUCTION                               DIG00630
C                                                                       DIG00640
450        IBYTE=LA                                                     DIG00650
           M(M1)=IBYTE                                                  DIG00660
           IF(IPRT.GE.20)WRITE(6,215)M1,IBYTE                           DIG00670
215        FORMAT(' DIGT$',I5,' LENGTH OF THIS INSTR IS',I3)            DIG00680
           M1=M1+1                                                      DIG00690
C                                                                       DIG00700
CC                                                                      DIG00710
C                                                                       DIG00720
           DO 35 I=1,LA                                                 DIG00730
15            IZ=FIND$(A$(I),LA,C$,LC,LOC)                              DIG00740
              IF(IZ.NE.0)GO TO 20                                       DIG00750
                 WRITE(6,207)M1                                         DIG00760
207              FORMAT(' ***** INVALID CHARACTER     *****',5X,I5)    DIG00770
                 DIGT$=-1                                               DIG00780
                 RETURN                                                 DIG00790
20            M(M1)=IZ+15                                               DIG00800
              IF(IPRT.GE.10)WRITE(6,208)M1,C$(IZ),M(M1)                 DIG00810
208           FORMAT(' DIGT$',I5,' DIGIT ENTRY INSTR     ',3X,A1,3X,    DIG00820
     2                                                    T75,I3)       DIG00830
              M1=M1+1                                                   DIG00840
35         CONTINUE                                                     DIG00850
C                                                                       DIG00860
CC                                                                      DIG00870
40      DIGT$=0                                                         DIG00880
        RETURN                                                          DIG00890
C                                                                       DIG00900
CC                                                                      DIG00910
CC                                                                      DIG00920
CC      ERROR HANDLING SECTION FOLLOWS                                  DIG00930
C                                                                       DIG00940
6000    WRITE(6,6001) FUNC$                                             DIG00950
6001    FORMAT(' *** STRING LENGTH ERROR *** ',A4)                      DIG00960
```

```
      WRITE(6,6010) LA,LB,IDIM                                          DIG00970
6010  FORMAT(' LA=',I10,'     LB=',I10,'     IDIM=',I10)                DIG00980
      DIGT$=-1                                                          DIG00990
      RETURN                                                            DIG01000
6999  WRITE(6,602)M1                                                    DIG01010
602   FORMAT(' ***** DIGIT ENTRY INSTR ERROR **',5X,I5)                 DIG01020
      DIGT$=-1                                                          DIG01030
      RETURN                                                            DIG01040
      END                                                               DIG01050
```

```
      INTEGER FUNCTION END$(A$,LA,M,M1)                                  END00010
C*****************************************************************END00020
C**                                                                 **END00030
C**    STRING A$ HAS BEEN IDENTIFIED TO CONTAIN AN END INSTRUCTION.  **END00040
C**                                                                 **END00050
C**                                                                 **END00060
C**                                                                 **END00070
C**    THE RETURN VALUE OF THE FUNCTION END$ IS SET AS FOLLOWS:     ** END00080
C**          0  =  CONTINUE TO COMPILE                              **END00090
C**         -1  =  AN ERROR IN COMPILING THE INSTRUCTION.           **END00100
C**                                                                 **END00110
C**                                                                 **END00120
C*****************************************************************END00130
      IMPLICIT INTEGER(A-Z)                                          END00140
      COMMON/TEXT/IDIM,IPRT                                          END00150
      COMMON/FLAGS/DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2  END00160
C                                                                    END00170
      COMMON/CNTR/P1,P2,P3,P4,P5,P6,P7,P8,P9,S1,S2                   END00180
C                                                                    END00190
C     THIS SUBROUTINE PASSES THE NUMBER OF ELEMENTS IN M VIA COMMON /CNTEND00200
C                                                                    END00210
      LOGICAL DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2       END00220
      INTEGER*4 P1,P2,P3,P4,P5,P6,P7,P8,P9,S1,S2                     END00230
      INTEGER*2 A$(IDIM)                                             END00240
C     INTEGER*2 BLNK/' '/                                            END00250
      INTEGER*4 FUNC$/'END'/                                         END00260
      INTEGER*4 M(1)                                                 END00270
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                   END00280
200   FORMAT(' TRACE ',I3,' END$    :  ',110A1)                      END00290
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                            END00300
C                                                                    END00310
C                                                                    END00320
C                                                                    END00330
C                                                                    END00340
C                                                                    END00350
C     END INSTRUCTION IS THREE BYTES LONG.  INDICATE LENGTH OF INSTR.END00360
C                                                                    END00370
         M(M1)=3                                                     END00380
         IF(IPRT.GE.20)WRITE(6,201)M1,IBYTE                          END00390
201      FORMAT('  END$',I5,' LENGTH OF NEXT INSTR IS',I3)           END00400
         M1=M1+1                                                     END00410
C                                                                    END00420
C                                                                    END00430
C                                                                    END00440
C     LOAD PREFIX CODE FOR END INSTRUCTION.  193 IS USED INSTEAD OF 192.END00450
C     WHILE 192 IS THE HP STANDARD OP-CODE FOR "END", THE 193 IS USED TOEND00460
C     ENABLE 192 TO STAND FOR AN ALPHA LABEL INSTRUCTION.  THIS USAGE  END00470
C     IS STANDARD AMONG THE HP USERS GROUP PRACTICING SYNTHETIC PROGRAM-END00480
```

```
C       MING.                                                                   END00490
C                                                                               END00500
           M(M1)=193                                                            END00510
           IF(IPRT.GE.10)WRITE(6,210)M1,M(M1)                                   END00520
210        FORMAT('  END$',I5,'        END    INSTR',T75,I3)                    END00530
           M1=M1+1                                                              END00540
C                                                                               END00550
CCC                                                                             END00560
CCC                                                                             END00570
C       PROVIDE TWO NULL INSTRUCTIONS TO RESERVE SPACE FOR THE LINK             END00580
C       POINTERS.  ALL ALPHANUMERIC LABEL AND END INSTRUCTIONS CONTAIN          END00590
C       POINTERS WHICH LINK THEM ALTOGETHER INTO A LABEL CHAIN.  THIS           END00600
C       CHAIN IS USED TO IDENTIFY THE POSITION OF LABELS AND PROGRAM            END00610
C       BOUNDARIES WITHIN THE HP41CV MEMORY.  THE CHAIN OF LABELS IS            END00620
C       RECOMPILED BY THE WAND SOFTWARE, SO THE BYTES CONTAINING THE            END00630
C       CHAIN ARE SET TO ZERO BY THIS COMPILER.                                 END00640
C                                                                               END00650
           M(M1)=0                                                              END00660
           IF(IPRT.GE.10)WRITE(6,211)M1,M(M1)                                   END00670
211        FORMAT('  END$',I5,' TRAILNG NULL INSTR',T75,I3)                    END00680
           M1=M1+1                                                              END00690
           M(M1)=0                                                              END00700
           IF(IPRT.GE.10)WRITE(6,212)M1,M(M1)                                   END00710
212        FORMAT('  END$',I5,' POINTER WILL BE RECOMPILED',T75,I3)            END00720
C                                                                               END00730
CCC                                                                             END00740
CCC                                                                             END00750
C       NOTE NUMBER OF ELEMENTS IN THE MACHINE CODE ARRAY AND SET END FLAG      END00760
C                                                                               END00770
           S2=M1                                                                END00780
           M1=M1+1                                                              END00790
C          DONE=.TRUE.                                                          END00800
           WRITE(6,202)S2                                                       END00810
202        FORMAT('1COMPILATION ENDED:',I5,' MACHINE CODES GENERATED')          END00820
           END$=1                                                               END00830
           RETURN                                                               END00840
C                                                                               END00850
CCC                                                                             END00860
C       ERROR HANDLING SECTION FOLLOWS                                          END00870
C                                                                               END00880
6000    WRITE(6,6001) FUNC$                                                     END00890
6001    FORMAT(' *** STRING LENGTH ERROR *** ',A4)                              END00900
        WRITE(6,6010) LA,LB,IDIM                                                END00910
6010    FORMAT(' LA=',I10,'     LB=',I10,'     IDIM=',I10)                      END00920
        END$=-1                                                                 END00930
        RETURN                                                                  END00940
        END                                                                     END00950
```

```
      INTEGER FUNCTION EQ$(A$,LA,B$,LB,NUM)                              EQ$00010
C*****************************************************************     EQ$00020
C**                                                                   **EQ$00030
C**     THIS FUNCTION  TESTS FOR STRING EQUALITY.  FOR THIS FUNCTION  **EQ$00040
C**     THE RETURN VALUE IS CRUCIAL AS IT CONTAINS THE RESULTS OF THE **EQ$00050
C**     TEST FOR EQUALITY.                                            **EQ$00060
C**                                                                   **EQ$00070
C**     NUM DEFINES THE NUMBER OF CHARACTERS TO BE EXAMINED FOR       **EQ$00080
C**     EQUALITY, STARTING FROM THE LEFT MOST POSITION OF BOTH        **EQ$00090
C**     STRINGS.  THUS, THE STRINGS:                                  **EQ$00100
C**                                                                   **EQ$00110
C**             A$='ABCDEFG' AND   B$='ABC'                           **EQ$00120
C**                                                                   **EQ$00130
C**     WILL BE "EQUAL" IF TESTED WITH  EQ$(A$,LA,B$,LB,LB)           **EQ$00140
C**     BUT "UNEQUAL" IF TESTED WITH    EQ$(A$,LA,B$,LB,LA)           **EQ$00150
C**                                                                   **EQ$00160
C**     TO TEST FOR ABSOLUTE EQUALITY, JUST ASIGN NUM TO BE SOME      **EQ$00170
C**     ARBITRARILY LARGE INTEGER,SAY 1000).  THE COMPARISON WILL     **EQ$00180
C**     TERMINATE APPROPRIATELY AT THE END OF THE SHORTEST STRING.    **EQ$00190
C**                                                                   **EQ$00200
C**     IE.      EQ$(A$,LA,B$,LB,IDIM) WILL TEST ABSOLUTE EQUALITY    **EQ$00210
C**                                                                   **EQ$00220
C**                                                                   **EQ$00230
C**     IT IS SUGGESTED THAT THIS ROUTINE BE USED IN AN ARITHMETIC    **EQ$00240
C**     IF STATEMENT OF THE FORM:                                     **EQ$00250
C**                                                                   **EQ$00260
C**          IF(EQ$(A$,LA,B$,LB,LA)) 6002, 10, 20                    **EQ$00270
C**                                                                   **EQ$00280
C**        WHERE:    6002 IS AN ERROR HANDLING ROUTINE                **EQ$00290
C**                  10   IS THE ROUTINE WHEN STRINGS ARE NOT EQUAL   **EQ$00300
C**                  20   IS THE ROUTINE WHEN STRINGS ARE EQUAL       **EQ$00310
C**                                                                   **EQ$00320
C*****************************************************************     EQ$00330
      COMMON/TEXT/IDIM,IPRT                                            EQ$00340
      INTEGER*2 A$(IDIM),B$(IDIM)                                      EQ$00350
      INTEGER*4 FUNC$/'EQ'/                                            EQ$00360
                                                                       EQ$00370
      INTEGER*4 LA,LB,NUM                                              EQ$00380
      IF(IPRT.GE.10) WRITE(6,200)LA,NUM,(A$(I),I=1,LA)                 EQ$00390
200   FORMAT(' TRACE ',I3,' EQ$(',I3,'):',110A1)                       EQ$00400
      IF(IPRT.GE.10)WRITE(6,199)LB,(B$(I),I=1,LB)                      EQ$00410
199   FORMAT('   AND ',I3,'       :  ',110A1)                          EQ$00420
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                              EQ$00430
      IF(LB.GT.IDIM.OR.LB.LT.0) GOTO 6000                              EQ$00440
C                                                                      EQ$00450
C                                                                      EQ$00460
C                                                                      EQ$00470
      LENGTH=NUM                                                       EQ$00480
```

```
      IF((LENGTH.LE.LA).AND.(LENGTH.LE.LB))GOTO  10                    EQ$00490
         IF(LA.NE.LB) GOTO 5                                           EQ$00500
            LENGTH=LA                                                  EQ$00510
            GOTO 10                                                    EQ$00520
C                                                                      EQ$00530
CC                                                                     EQ$00540
C     STRINGS CAN NOT BE EQUAL BECAUSE HAVE BEEN ASKED TO EXAMINE      EQ$00550
C     MORE CHARACTERS THAN SMALLEST STRING IN A COMPARISON OF UNEQUAL   EQ$00560
C     STRINGS.                                                         EQ$00570
C                                                                      EQ$00580
5     EQ$=0                                                            EQ$00590
      IF(IPRT.GE.20)WRITE(6,202)                                       EQ$00600
      RETURN                                                           EQ$00610
C                                                                      EQ$00620
CC                                                                     EQ$00630
CCC                                                                    EQ$00640
C     EXAMINE CHARACTERS ONE-BY-ONE TO TEST FOR EQUALITY.              EQ$00650
C                                                                      EQ$00660
10    DO 15 I=1,LENGTH                                                 EQ$00670
         IF(IPRT.GE.30) WRITE(6,201) I,A$(I),I,B$(I)                   EQ$00680
201      FORMAT(' COMPARE A$(',I3,')=',A1,' WITH B$(',I3,')=',A1)      EQ$00690
         IF(A$(I).EQ.B$(I)) GOTO 15                                    EQ$00700
              EQ$=0                                                    EQ$00710
              IF(IPRT.GE.20)WRITE(6,202)I                              EQ$00720
202           FORMAT(' STRINGS FOUND UNEQUAL',I3,' POSITION')          EQ$00730
              RETURN                                                   EQ$00740
15    CONTINUE                                                         EQ$00750
C                                                                      EQ$00760
CC                                                                     EQ$00770
C     IF YOU GET BELOW HERE THE STRINGS WERE FOUND TO BE EQUAL         EQ$00780
C                                                                      EQ$00790
      EQ$=1                                                            EQ$00800
      IF(IPRT.GE.20)WRITE(6,203)                                       EQ$00810
203   FORMAT(' STRINGS FOUND   EQUAL')                                 EQ$00820
      RETURN                                                           EQ$00830
C                                                                      EQ$00840
C     ERROR HANDLING SECTION FOLLOWS                                   EQ$00850
C                                                                      EQ$00860
6000  WRITE(6,6001) FUNC$                                              EQ$00870
6001  FORMAT(' *** STRING LENGTH ERROR *** ',A4)                       EQ$00880
      WRITE(6,6010) LA,LB,IDIM                                         EQ$00890
6010  FORMAT(' LA=',I10,'     LB=',I10,'     IDIM=',I10)               EQ$00900
      EQ$=-9999                                                        EQ$00910
      RETURN                                                           EQ$00920
      END                                                              EQ$00930
```

```
      INTEGER FUNCTION FIND$(A$,LA,B$,LB,LOC)                          FIN00010
C*****************************************************************FIN00020
C**                                                                 **FIN00030
C**   "FIND A$ IN B$."                                              **FIN00040
C**                                                                 **FIN00050
C**   STRING B$ IS SEARCHED FOR THE FIRST OCCURANCE OF A MATCH WITH **FIN00060
C**   CHARACTER A$.  A$ IS NOT ALLOWED TO BE MORE THAN ONE CHARACTER **FIN00070
C**   IN LENGTH.                                                    **FIN00080
C**                                                                 **FIN00090
C**   SINCE B$ IS MOST LIKELY A TABLE OF CHARACTERS, IT IS ALLOWED, **FIN00100
C**   AND MOST OFTEN IS OF A GREATER DIMENSION THAN IDIM, THE STANDARD **FIN00110
C**   STRING DIMENSION.                                             **FIN00120
C**                                                                 **FIN00130
C**    THE VALUE OF THE FUNCTION FIND$ IS SET TO                    **FIN00140
C**          LOC (LOCATION OF FIRST MATCH IN B$) IF MATCH FOUND     **FIN00150
C**            0 NO MATCH IS FOUND                                  **FIN00160
C**           -1 IF AN ERROR IS ENCOUNTERED.                        **FIN00170
C**                                                                 **FIN00180
C*****************************************************************FIN00190
      IMPLICIT INTEGER(A-Z)                                          FIN00200
      COMMON/TEXT/IDIM,IPRT                                          FIN00210
      INTEGER*2 A$(1),B$(IDIM)                                       FIN00220
      INTEGER*2 OBJECT                                               FIN00230
      INTEGER*4 FUNC$/'FIND'/                                        FIN00240
      INTEGER*4 LOC,FIND$                                            FIN00250
      IF(IPRT.GE.10) WRITE(6,200)LA,A$(1)                            FIN00260
200   FORMAT(' TRACE ',I3,' FIND$   :  ',110A1)                      FIN00270
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                            FIN00280
      IF(LB.GT.IDIM.OR.LB.LT.0) GOTO 6000                            FIN00290
C                                                                    FIN00300
C                                                                    FIN00310
C                                                                    FIN00320
      OBJECT=A$(1)                                                   FIN00330
      INDEX=1                                                        FIN00340
      DO 25 I=1,LB                                                   FIN00350
         IF(IPRT.GE.40) WRITE(6,211) OBJECT,I,B$(I)                  FIN00360
211      FORMAT(' COMPARE OBJECT=',A1,' WITH B$(',I3,')=',A1)        FIN00370
         IF(OBJECT.EQ.B$(INDEX))GOTO 30                              FIN00380
         INDEX=INDEX+1                                               FIN00390
25    CONTINUE                                                       FIN00400
C                                                                    FIN00410
C                                                                    FIN00420
C                                                                    FIN00430
C     NO MATCH FOUND                                                 FIN00440
C                                                                    FIN00450
      LOC=0                                                          FIN00460
      FIND$=0                                                        FIN00470
      IF(IPRT.GE.20)WRITE(6,201)LOC                                  FIN00480
```

```
201   FORMAT(' NO SINGLE CHARACTER MATCH FOUND',I2)                    FIN00490
      RETURN                                                           FIN00500
C                                                                      FIN00510
C                                                                      FIN00520
C                                                                      FIN00530
C     HAVE FOUND A MATCH                                               FIN00540
C                                                                      FIN00550
30    LOC=INDEX                                                        FIN00560
      FIND$=INDEX                                                      FIN00570
      IF(IPRT.GE.30)WRITE(6,202)LOC                                    FIN00580
202   FORMAT(' HAVE FOUND SINGLE CHARACTER MATCH AT',I3)               FIN00590
      RETURN                                                           FIN00600
C                                                                      FIN00610
C                                                                      FIN00620
C                                                                      FIN00630
C     ERROR HANDLING SECTION FOLLOWS                                   FIN00640
C                                                                      FIN00650
6000  WRITE(6,6001) FUNC$                                              FIN00660
6001  FORMAT(' *** STRING LENGTH ERROR *** ',A4)                       FIN00670
      WRITE(6,6010) LA,LB,IDIM                                         FIN00680
6010  FORMAT(' LA=',I10,'     LB=',I10,'     IDIM=',I10)               FIN00690
      FIND$=-1                                                         FIN00700
      RETURN                                                           FIN00710
      END                                                              FIN00720
```

```
      INTEGER FUNCTION GTO$(A$,LA,M,M1)                                 GT000010
C*****************************************************************GT000020
C**                                                                 **GT000030
C**    STRING A$  HAS BEEN IDENTIFIED TO CONTAIN A GTO INSTRUCTION.  **GT000040
C**                                                                 **GT000050
C**    THE RETURN VALUE OF THE FUNCTION GTO$ IS SET AS FOLLOWS:     **  GT000060
C**          0   =  CONTINUE TO COMPILE                            **GT000070
C**         -1   =  AN ERROR IN COMPILING THE INSTRUCTION.          **GT000080
C**                                                                 **GT000090
C**                                                                 **GT000100
C*****************************************************************GT000110
      IMPLICIT INTEGER(A-Z)                                             GT000120
      COMMON/TEXT/IDIM,IPRT                                             GT000130
      COMMON/FLAGS/DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2     GT000140
      COMMON/CNTR/P1,P2,P3,P4,P5,P6,P7,P8,P9,S1,S2                      GT000150
      LOGICAL DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2          GT000160
      INTEGER*4 P1,P2,P3,P4,P5,P6,P7,P8,P9,S1,S2                        GT000170
      INTEGER*2 A$(IDIM)                                                GT000180
      INTEGER*2 BLNK/' '/                                               GT000190
      INTEGER*2 QUOTE/'"'/                                              GT000200
      INTEGER*2 IND(3)/'I','N','D'/                                     GT000210
      INTEGER*2 LABEL(26)/'A','B','C','D','E','F','G','H','I','J',     GT000220
     2                    'T','Z','Y','X','L',' ',' ',' ',' ',' ',     GT000230
     3                    ' ',' ',' ',' ',' ',' ',' ',' '/             GT000240
      INTEGER*4 FUNC$/'GTO'/                                            GT000250
      INTEGER*4 M(1)                                                    GT000260
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                      GT000270
200   FORMAT(' TRACE ',I3,' GTO$    :  ',110A1)                         GT000280
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                               GT000290
C                                                                       GT000300
CCC                                                                     GT000310
C                                                                       GT000320
C     ESTABLISH DEFAULT PREFIX AND INSTRUCTION LENGTH VALUES            GT000330
C     (THESE ARE THE VALUES FOR 3 BYTE LOCAL NUMERIC GOTO WITHOUT IND)  GT000340
C                                                                       GT000350
         IBYTE=3                                                        GT000360
         PREFIX=208                                                     GT000370
C                                                                       GT000380
CCC                                                                     GT000390
C                                                                       GT000400
C     STRIP STRING OF "GTO" CHARACTERS.                                 GT000410
C                                                                       GT000420
         CALL LCUT$(A$,LA,3)                                            GT000430
         IF(TRIM$(A$,LA)) 6015,6015,10                                  GT000440
C                                                                       GT000450
CCC                                                                     GT000460
C                                                                       GT000470
C     CHECK FOR ALPHANUMERIC VERSUS LOCAL LABELS                        GT000480
```

```
C                                                                       GT000490
10        IF(A$(1).EQ.QUOTE) GOTO 80                                    GT000500
C                                                                       GT000510
CCC                                                                     GT000520
CCC                                                                     GT000530
CCC     PROCESS LOCAL LABELS, FIRST CHECK FOR INDIRECT GTO INSTR        GT000540
C                                                                       GT000550
          P1=POS$(A$,LA,BLNK,1,1)                                       GT000560
          IF(P1) 6015,20,15                                             GT000570
C                                                                       GT000580
CCC                                                                     GT000590
CCC                                                                     GT000600
CCC     PROCESS GTO INDIRECT INSTRUCTION.                               GT000610
C                                                                       GT000620
15        IF(EQ$(A$,LA,IND,3,3)) 6015,6020,16                           GT000630
16        CALL LCUT$(A$,LA,P1)                                          GT000640
          IF(IPRT.GE.20)WRITE(6,235)                                    GT000650
235       FORMAT(' DETECTED INDIRECT GOTO INSTRUCTION')                 GT000660
          INDIR=.TRUE.                                                  GT000670
          IBYTE=2                                                       GT000680
          PREFIX=174                                                    GT000690
C                                                                       GT000700
CCC                                                                     GT000710
CCC                                                                     GT000720
CCC     CHECK FOR NUMERIC OPERAND                                       GT000730
C                                                                       GT000740
20        IF(NUMC$(A$,LA,IANSW)) 6015,25,5)                             GT000750
C                                                                       GT000760
CCC                                                                     GT000770
CCC                                                                     GT000780
CCC                                                                     GT000790
CCC                                                                     GT000800
CCC     OPERAND MUST BE REGISTER X,Y,Z,T CR L  OR A LOCAL ALPHA LABEL   GT000810
C                                                                       GT000820
25        DO 30 I=1,26                                                  GT000830
              INDEX=I                                                   GT000840
              IF(A$(1).EQ.LABEL(I)) GOTO 35                             GT000850
30        CONTINUE                                                      GT000860
C                                                                       GT000870
C         WILL FALL THROUGH TO THIS CODE IF NO VALID LABEL FOUND        GT000880
          GOTO 6015                                                     GT000890
C                                                                       GT000900
CCC                                                                     GT000910
CCC                                                                     GT000920
CCC     HAVE FOUND A MATCH IN LOCAL LABEL TABLE, SET VALUE OF SECOND OPER-GT000930
C       AND.  THEN GOTO PROCESS A THREE BYTE INSTRUCTION.               GT000940
C                                                                       GT000950
35        INDEX=INDEX+101                                               GT000960
```

```
          GOTO 75                                                          GT000970
C                                                                          GT000980
C                                                                          GT000990
C                                                                          GT001000
C                                                                          GT001010
C                                                                          GT001020
C     OPERAND  MUST BE A NUMERIC LOCAL LABEL                               GT001030
C                                                                          GT001040
50        IF(IVAL$(A$,LA,INDEX))6015,55,55                                 GT001050
C                                                                          GT001060
C                                                                          GT001070
C                                                                          GT001080
C     HAVE FOUND VALID NUMERIC LOCAL LABEL, CHECK FOR TWO BYTE INSTR       GT001090
C                                                                          GT001100
55        IF(INDEX.GT.14.OR.INDIR) GOTO 75                                 GT001110
C                                                                          GT001120
C                                                                          GT001130
C                                                                          GT001140
C     PROCESS A TWO BYTE INSTRUCTION, FIRST LOAD THE LENGTH OF INSTR       GT001150
C                                                                          GT001160
          IBYTE=2                                                          GT001170
          M(M1)=IBYTE                                                      GT001180
          IF(IPRT.GE.20)WRITE(6,210)M1,IBYTE                               GT001190
          M1=M1+1                                                          GT001200
C                                                                          GT001210
C                                                                          GT001220
C                                                                          GT001230
C     HAVE FOUND VALID NUMERIC LOCAL LABEL <15, LOAD "GTO" INSTRUCTION     GT001240
C                                                                          GT001250
          M(M1)=177+INDEX                                                  GT001260
          IF(IPRT.GE.10)WRITE(6,213)M1,M(M1)                               GT001270
213       FORMAT('  GTO$',I5,' TWO BYTE GTO INSTR',T75,I3)                 GT001280
          M1=M1+1                                                          GT001290
C                                                                          GT001300
C                                                                          GT001310
C                                                                          GT001320
C     LOAD NULL INSTR FOR TWO BYTE GTO INSTR  AND RETURN                   GT001330
C                                                                          GT001340
          M(M1)=0                                                          GT001350
          IF(IPRT.GE.10)WRITE(6,221)M1,M(M1)                               GT001360
          M1=M1+1                                                          GT001370
          GTO$=0                                                           GT001380
          RETURN                                                           GT001390
C                                                                          GT001400
C                                                                          GT001410
C                                                                          GT001420
C      PROCESS   THE GOTO   INSTRUCTION  (OPERAND>14)                      GT001430
C                                                                          GT001440
```

```
75        M(M1)=IBYTE                                                          GT001450
          IF(IPRT.GE.20)WRITE(6,210)M1,IBYTE                                   GT001460
210       FORMAT('  GTO$',I5,' LENGTH OF NEXT INSTR IS',I3)                    GT001470
          M1=M1+1                                                              GT001480
C                                                                              GT001490
CC                                                                             GT001500
CC                                                                             GT001510
C     LOAD    THE     GTO INSTR  PREFIX                                        GT001520
C                                                                              GT001530
          M(M1)=PREFIX                                                         GT001540
          IF(IPRT.GE.10)WRITE(6,211)M1,M(M1)                                   GT001550
211       FORMAT('  GTO$',I5,' GTO PREFIX     INSTR',T75,I3)                   GT001560
          M1=M1+1                                                              GT001570
C                                                                              GT001580
CC                                                                             GT001590
CC                                                                             GT001600
C     LOAD THREE BYTE GOTO INSTR NULL INSTR (POSITION HOLDER FOR POINTERGT001610
C                                                                              GT001620
          IF(INDIR) GOTO 95                                                    GT001630
          M(M1)=0                                                              GT001640
          IF(IPRT.GE.10)WRITE(6,221)M1,M(M1)                                   GT001650
221       FORMAT('  GTO$',I5,' NULL  FOR  GTO INSTR',T75,I3)                   GT001660
          M1=M1+1                                                              GT001670
C                                                                              GT001680
CC                                                                             GT001690
CC                                                                             GT001700
C     LOAD THE 2D OPERAND OF THE         GTO INSTR                             GT001710
C                                                                              GT001720
C95       IF(INDIR) INDEX=INDEX+128                                            GT001730
C         NOTE THAT FOR GTO IND THE HIGH ORDER BIT IS NOT SET                  GT001740
95        M(M1)=INDEX                                                          GT001750
          IF(IPRT.GE.10)WRITE(6,212)M1,M(M1)                                   GT001760
212       FORMAT('  GTO$',I5,' GTO 2D OPERAND     ',T75,I3)                    GT001770
          M1=M1+1                                                              GT001780
          GTO$=0                                                               GT001790
          RETURN                                                               GT001800
C                                                                              GT001810
CC                                                                             GT001820
C*****************************************************************************GT001830
C*****************************************************************************GT001840
C                                                                              GT001850
CC                                                                             GT001860
C     PROCESS ALPHANUMERIC LABEL, FIRST LOOK FOR SECOND QUOTE                  GT001870
C                                                                              GT001880
80        K=0                                                                  GT001890
          P2=POS$(A$,LA,QUOTE,1,2)                                             GT001900
          IF(P2) 6015,120,85                                                   GT001910
C                                                                              GT001920
```

```
C                                                                       GT001930
C                                                                       GT001940
CCCC      CHECK AFTER LAST QUOTE FOR BOGUS CHARACTERS                   GT001950
CCCC                                                                    GT001960
85           LEFT=LA-P2                                                 GT001970
             IF(LEFT) 6015,100,6015                                     GT001980
C                                                                       GT001990
CCCCC     DELETE THE ENDING QUOTE BY TRUNCATING THE STRING ONE CHAR     GT002000
CCCCC                                                                   GT002010
100          LA=LA-1                                                    GT002020
CCCCC                                                                   GT002030
CCCCCC                                                                  GT002040
CCCCCC    SET INSTRUCTION LENGTH FOR ALPHABETIC GLOBAL LABEL            GT002050
C   (LINE 120 ACCOUNTS FOR BEGINNING QUOTE STILL ON STRING)             GT002060
C                                                                       GT002070
120          LENGTH=LA-1                                                GT002080
C            FOR GTO H=2      FOR LBL H=4          FOR XEQ H=2         GT002090
             H=2                                                        GT002100
             IBYTE=H+LENGTH                                             GT002110
             M(M1)=IBYTE                                                GT002120
             IF(IPRT.GE.20)WRITE(6,210)M1,IBYTE                         GT002130
             M1=M1+1                                                    GT002140
C                                                                       GT002150
CCCCC                                                                   GT002160
CCCCC     HAVE FOUND VALID ALPHANUMERIC  LABEL,     LOAD "GTO" INSTRUCTION GT002170
C                                                                       GT002180
             PREFIX=29                                                  GT002190
C            FOR GTO PREFIX=29    FOR LBL PREFIX=192    FOR XEQ PREFIX=30 GT002200
             M(M1)=PREFIX                                               GT002210
             IF(IPRT.GE.10)WRITE(6,214)M1,M(M1)                         GT002220
214          FORMAT(' GTO$',I5,' ALPHA    GTO INSTR',T75,I3)            GT002230
             M1=M1+1                                                    GT002240
C                                                                       GT002250
CCCCC                                                                   GT002260
CCCCC                                                                   GT002270
CCCCC                                                                   GT002280
CCCCC     SET INDICATOR FOR NUMBER OF ALPHA CHARS IN LABEL              GT002290
C                                                                       GT002300
             U=240                                                      GT002310
C            FOR GTO U=240     FOR LBL   U=241        FOR XEQ U=240    GT002320
             M(M1)=U+LENGTH                                             GT002330
             IF(IPRT.GE.10)WRITE(6,216)M1,M(M1)                         GT002340
216          FORMAT(' GTO$',I5,' LENGTH CODE ALPH GTO',T75,I3)          GT002350
             M1=M1+1                                                    GT002360
```

```
C                                                                       GT002410
CC                                                                      GT002420
CCC                                                                     GT002430
CCCC                                                                    GT002440
CCCCC                                                                   GT002450
CCCCC     ADD ALPHABETIC CHARACTERS AND RETURN                          GT002460
C                                                                       GT002470
140       LA=LENGTH+1                                                   GT002480
          GTO$=ALPH$(A$,LA,M,M1)                                        GT002490
          RETURN                                                        GT002500
C                                                                       GT002510
CC                                                                      GT002520
CCC       ERROR HANDLING SECTION FOLLOWS                                GT002530
CCCC                                                                    GT002540
6000  WRITE(6,6001) FUNC$                                               GT002550
6001  FORMAT(' *** STRING LENGTH ERROR *** ',A4)                        GT002560
      WRITE(6,6010) LA,LB,IDIM                                          GT002570
6010  FORMAT(' LA=',I10,'     LB=',I10,'     IDIM=',I10)                GT002580
      GTO$=-1                                                           GT002590
      RETURN                                                            GT002600
6015  WRITE(6,6016)                                                     GT002610
6016  FORMAT(' ***** INVALID SECOND OPERAND IN GTO INSTR ****')         GT002620
      GTO$=-1                                                           GT002630
      RETURN                                                            GT002640
6020  WRITE(6,6021)                                                     GT002650
6021  FORMAT(' ***** FOUND THREE OPERANDS, EXPECTING IND *****')        GT002660
      GTO$=-1                                                           GT002670
      RETURN                                                            GT002680
      END                                                               GT002690
```

```
      INTEGER FUNCTION IN$(A$,LA,IN)                                    IN$00010
C*****************************************************************IN$00020
C**                                                                 **IN$00030
C**    STRING A$ IS READ FROM UNIT IN.                              **IN$00040
C**                                                                 **IN$00050
C**    THE LENGTH OF A$ IS AUTOMATICALLY COMPUTED, NOT COUNTING ANY **IN$00060
C**    LEADING OR TRAILING BLANKS, WHICH ARE TRIMMED AWAY.          **IN$00070
C**                                                                 **IN$00080
C**    THE INPUT READER ASSUMES AN FIXED LENGTH INPUT RECORD OF 80  **IN$00090
C**    CHARS.                                                       **IN$00100
C**                                                                 **IN$00110
C*****************************************************************IN$00120
      IMPLICIT INTEGER(A-Z)                                         IN$00130
      COMMON/TEXT/IDIM,IPRT                                         IN$00140
      INTEGER*2 A$(IDIM)                                            IN$00150
      INTEGER*2 BLNK/' '/                                           IN$00160
      INTEGER*2 CARD(80)                                            IN$00170
      INTEGER*4 FUNC$/'IN'/                                         IN$00180
      LOGICAL EOFILE(10)/10*.FALSE./                                IN$00190
100   FORMAT(80A1)                                                  IN$00200
C                                                                   IN$00210
C                                                                   IN$00220
C                                                                   IN$00230
C     CHECK FOR END OF FILE                                         IN$00240
C                                                                   IN$00250
      IF(.NOT.EOFILE(IN)) GOTO 5                                    IN$00260
         IN$=-1                                                     IN$00270
         LA=0                                                       IN$00280
         IF(IPRT.GE.20) WRITE(6,201) IN                             IN$00290
201      FORMAT(' ATTEMPT TO READ AFTER END OF FILE ON UNIT ',I2)   IN$00300
         RETURN                                                     IN$00310
C                                                                   IN$00320
C                                                                   IN$00330
C                                                                   IN$00340
C     READ THE ACTUAL CARD                                          IN$00350
C                                                                   IN$00360
5     READ (IN,100,END=999) (CARD(I),I=1,80)                        IN$00370
      IF(IPRT.GE.20) WRITE(6,222)(CARD(I),I=1,78)                   IN$00380
222   FORMAT(' ',78A1)                                              IN$00390
C                                                                   IN$00400
C                                                                   IN$00410
C                                                                   IN$00420
C     CHECK CARD FOR TRAILING BLANKS                                IN$00430
C                                                                   IN$00440
58    IM=0                                                          IN$00450
      DO 60 I=1,80                                                  IN$00460
         INDEX=81-I                                                 IN$00470
         IF(CARD(INDEX).NE.BLNK) GOTO 65                            IN$00480
```

```
          IM=IM+1                                                                IN$00490
60        CONTINUE                                                               IN$00500
65        IF(IM.EQ.0) GOTO 70                                                    IN$00510
             IF(IPRT.GE.20) WRITE(6,207) IM                                      IN$00520
207          FORMAT(' FOUND',I3,' TRAILING BLANKS IN INPUT STRING')              IN$00530
             IF(IM.NE.80) GOTO 70                                                IN$00540
                  LA=0                                                           IN$00550
                  IN$=0                                                          IN$00560
                  IF(IPRT.GE.20) WRITE(6,208)                                    IN$00570
208               FORMAT(' FOUND INPUT STRING IS ALL BLANKS')                    IN$00580
                  IF(IPRT.GE.20) WRITE(6,200)LA,(A$(I),I=1,LA)                   IN$00590
                  RETURN                                                         IN$00600
70           IEND=80-IM                                                          IN$00610
C                                                                                IN$00620
CC                                                                               IN$00630
CC                                                                               IN$00640
CC        CHECK CARD FOR LEADING BLANKS                                          IN$00650
CC                                                                               IN$00660
C                                                                                IN$00670
          IM=0                                                                   IN$0068)
          DO 10 I=1,IEND                                                         IN$00690
             IF(CARD(I).NE.BLNK) GOTO 15                                         IN$00700
             IM=IM+1                                                             IN$00710
10        CONTINUE                                                               IN$00720
15        IF(IM.EQ.0) GOTO 25                                                    IN$00730
             IF(IPRT.GE.20) WRITE(6,211) IM                                      IN$00740
211          FORMAT(' FOUND',I3,' LEADING BLANKS IN INPUT STRING')               IN$00750
25           IBEG=1+IM                                                           IN$00760
C                                                                                IN$00770
CC                                                                               IN$00780
CC                                                                               IN$00790
CC        DETERMINE LENGTH OF INPUT STRING                                       IN$00800
C                                                                                IN$00810
          LA=IEND-IBEG+1                                                         IN$00820
          IF(LA.LE.IDIM) GOTO 30                                                 IN$00830
               LOSS=LA-IDIM                                                      IN$00840
               IF(IPRT.GE.10) WRITE(6,216) LOSS                                  IN$00850
216            FORMAT(' STRING TOO LONG FOR MAX STRING LENGTH.  LOST',I3)        IN$00860
               LA=IDIM                                                           IN$00870
               IEND=IEND-LOSS                                                    IN$00880
C                                                                                IN$00890
CC                                                                               IN$00900
CC                                                                               IN$00910
CC        TRANSFER THE CARD CHARACTERS TO THE INPUT STRING.                      IN$00920
C                                                                                IN$00930
3)        INDEX=1                                                                IN$00940
          DO 85 I=IBEG,IEND                                                      IN$00950
             A$(INDEX)=CARD(I)                                                   IN$00960
```

```
            IF(IPRT.GE.30) WRITE(6,209) I,CARD(I),INDEX,A$(INDEX)          IN$00970
209         FORMAT(' MOVE CARD(',I3,')=',A1,'  IS NOW C(',I3,')=',A1)      IN$00980
            INDEX=INDEX+1                                                  IN$00990
85      CONTINUE                                                           IN$01000
C                                                                          IN$01010
CC                                                                         IN$01020
CC                                                                         IN$01030
C       CHECK FOR STRING ERROR  AND RETURN                                 IN$01040
C                                                                          IN$01050
        IF(IPRT.GE.20) WRITE(6,200)LA,(A$(I),I=1,LA)                       IN$01060
200     FORMAT(' TRACE ',I3,' IN$    :  ',110A1)                           IN$01070
        IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                                IN$01080
        IN$=LA                                                             IN$01090
        RETURN                                                             IN$01100
C                                                                          IN$01110
CC                                                                         IN$01120
CC                                                                         IN$01130
C       HANDLE END OF FILE CONDITION                                       IN$01140
C                                                                          IN$01150
999     ECFILE(IN)=.TRUE.                                                  IN$01160
        IN$=-1                                                             IN$01170
        LA=0                                                               IN$01180
        IF(IPRT.GE.20) WRITE(6,215)                                        IN$01190
215     FORMAT(' END OF FILE ENCOUNTERED')                                 IN$01200
        RETURN                                                             IN$01210
C                                                                          IN$01220
CC                                                                         IN$01230
CC                                                                         IN$01240
C       ERROR HANDLING SECTION FOLLOWS                                     IN$01250
C                                                                          IN$01260
6000    WRITE(6,6001) FUNC$                                                IN$01270
6001    FORMAT(' *** STRING LENGTH ERROR *** ',A4)                         IN$01280
        IN$=-1                                                             IN$01290
        RETURN                                                             IN$01300
        END                                                                IN$01310
```

```
      INTEGER FUNCTION IONE$(A$,LA,M,M1,IBYTE)                          ION00010
C*****************************************************************    ION00020
C**                                                                   **ION00030
C**   THIS FUNCTION IS THE TABLE DRIVEN INSTRUCTION LOOKUP.  IT IS    **ION00040
C**   USED TO TRANSLATE THE ONE BYTE INSTRUCTIONS IN THE HP41C        **ION00050
C**   COMPILER.                                                       **ION00060
C**                                                                   **ION00070
C**                                                                   **ION00080
C*****************************************************************    ION00090
      IMPLICIT INTEGER(A-Z)                                             ION00100
      COMMON/TEXT/IDIM,IPRT                                             ION00110
      COMMON/FLAGS/DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2     ION00120
      LOGICAL DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2          ION00130
      COMMON/TABLE/INST$,LINST,CODE,NINST                               ION00140
      INTEGER*2 INST$(6,111)                                            ION00150
      INTEGER*4 LINST(111),CODE(111),NINST                              ION00160
      INTEGER*2 A$(IDIM)                                                ION00170
      INTEGER*4 FUNC$/'IONE'/                                           ION00180
      INTEGER*4 M(1)                                                    ION00190
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                      ION00200
200   FORMAT(' TRACE ',I3,' IONE$    :  ',110A1)                        ION00210
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                               ION00220
C                                                                       ION00230
CCC                                                                     ION00240
CCC                                                                     ION00250
C                                                                       ION00260
      DO 50 I=1,NINST                                                   ION00270
         LENGTH=LINST(I)                                                ION00280
         IF(LA.NE.LENGTH) GOTO 50                                       ION00290
         DO 30 J=1,LENGTH                                               ION00300
            IF(A$(J).NE.INST$(J,I))GOTO 50                              ION00310
30       CONTINUE                                                       ION00320
C                                                                       ION00330
C                                                                       ION00340
C        INSTRUCTION MATCHES SO CHECK TO SEE IF CORRECT NUMBER          ION00350
C        OPERANDS.  INSTRUCTIONS 143 OR LESS MUST HAVE ONLY ONE         ION00360
C        OPERAND.  INSTRUCTIONS 144 OR MORE MUST HAVE MORE THAN ONE.    ION00370
C                                                                       ION00380
         IF(IBYTE.EQ.1.AND.CODE(I).LE.143) GOTO 35                      ION00390
         IF(IBYTE.EQ.2.AND.CODE(I).GT.143) GOTO 35                      ION00400
         GOTO 6020                                                      ION00410
C                                                                       ION00420
CCC                                                                     ION00430
CCC                                                                     ION00440
C        LOAD CORRECTLY MATCHING VALUES TO MACHINE CODE ARRAY           ION00450
C                                                                       ION00460
35       M(M1)=IBYTE                                                    ION00470
         IF(IPRT.GE.20)WRITE(6,212)M1,IBYTE                             ION00480
```

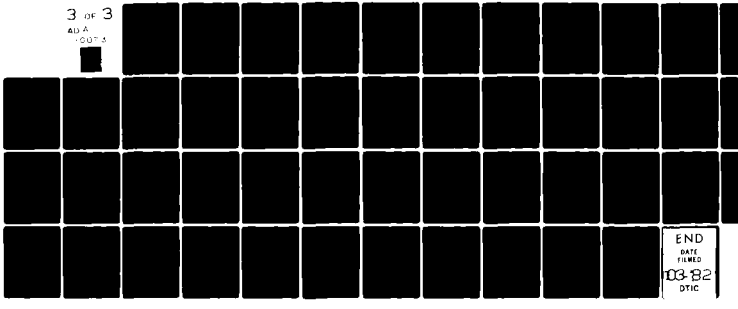
```
212       FORMAT(' IONE$',I5,' LENGTH OF NEXT INSTR IS',I3)                    ION00490
          M1=M1+1                                                              ION00500
          M(M1)=CODE(I)                                                        ION00510
          IF(IPRT.GE.10)WRITE(6,210)M1,(INST$(JJ,I),JJ=1,6),M(M1)              ION00520
210       FORMAT(' IONE$',I5,' ',6A1,'  INSTR',T75,I3)                         ION00530
          M1=M1+1                                                              ION00540
C         IF(LA.GT.LENGTH) GOTO 35                                             ION00550
               LA=0                                                            ION00560
               IONE$=0                                                         ION00570
               RETURN                                                          ION00580
C                                                                              ION00590
CCCCC                                                                          ION00600
CCCCC     FOLLOWING COMMENT LINES HAVE BEEN RETAINED TO FACILITATE USE OF      ION00610
CCCCC     PROGRAM UNDER RULE THAT THE LENGTH OF A$ MAY BE MORE THAN THE        ION00620
CCCCC     LENGTH OF THE MATCH STRING.  CODE HAS BEEN TESTED AND PROVEN TO      ION00630
CCCCC     SELECT FIRST SUBSTRING MATCH IN TABLE.                               ION00640
CCCCC                                                                          ION00650
CCCCC35      LEFT=LA-LENGTH                                                    ION00660
CCCCC        LSTART=LENGTH+1                                                   ION00670
CCCCC        IF(SEG$(A$,LA,A$,LA,LSTART,LEFT).GT.0) GOTO 40                    ION00680
CCCCC              IONE$=0                                                     ION00690
CCCCC              RETURN                                                      ION00700
CCCCC40      IONE$=LA                                                          ION00710
CCCCC        RETURN                                                            ION00720
CCCCC                                                                          ION00730
CCCCC                                                                          ION00740
CCCCC     INSTRUCTION DOES NOT MATCH SO CHECK NEXT INSTRUCTION                 ION00750
CCCCC                                                                          ION00760
CCCCC50   CONTINUE                                                             ION00770
CCCCC                                                                          ION00780
CCCCC     NO MATCH FOUND                                                       ION00790
CCCCC                                                                          ION00800
CCCCC60   WRITE(6,215)                                                         ION00810
215       FORMAT(' ***** UNRECOGNIZABLE INSTRUCTION ****')                     ION00820
             M(M1)=IBYTE                                                       ION00830
             IF(IPRT.GE.20)WRITE(6,212)M1,IBYTE                                ION00840
             M1=M1+1                                                           ION00850
             M(M1)=0                                                           ION00860
             IF(IPRT.GE.10)WRITE(6,211)M1,M(M1)                                ION00870
211          FORMAT(' IONE$',I5,' NULL          INSTR',T75,I3)                 ION00880
             M1=M1+1                                                           ION00890
C                                                                              ION00900
          IONE$=-1                                                             ION00910
          RETURN                                                               ION00920
C                                                                              ION00930
                                                                               ION00940
                                                                               ION00950
                                                                               ION00960
```

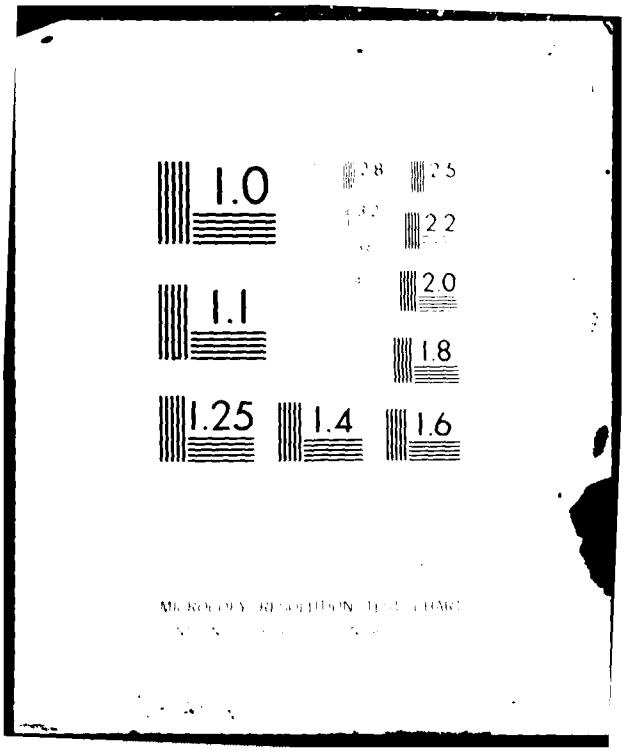
```
C       ERROR HANDLING SECTION FOLLOWS                                          ION00970
C                                                                               ION00980
6000    WRITE(6,6001) FUNC$                                                     ION00990
6001    FORMAT(' *** STRING LENGTH ERROR *** ',A4)                              ION01000
        WRITE(6,6010) LA,LB,IDIM                                                ION01010
6010    FORMAT(' LA=',I10,'     LB=',I10,'     IDIM=',I10)                      ION01020
        ICNE$=-1                                                                ION01030
        RETURN                                                                  ION01040
6020    WRITE(6,6021)                                                           ION01050
6021    FORMAT(' *** LENGTH OF INSTRUCTION DOES NOT MATCH NUMBER OPERNDS')      ION01060
        IONE$=-1                                                                ION01070
        RETURN                                                                  ION01080
        END                                                                     ION01090
```

```
      INTEGER FUNCTION IRDR$(IDEV,VAL)                                  IRD00010
C*****************************************************************    IRD00020
C**                                                                   **IRD00030
C**     THIS FUNCTION READS A FREE FORMAT VALUE AND CONVERTS IT TO     **IRD00040
C**     AN INTEGER.                                                   **IRD00050
C**                                                                   **IRD00060
C**                                                                   **IRD00070
C**                                                                   **IRD00080
C*****************************************************************    IRD00090
      IMPLICIT INTEGER(A-Z)                                             IRD00100
      COMMON/TEXT/IDIM,IPRT                                             IRD00110
      INTEGER*2 A$(80)                                                  IRD00120
      INTEGER*2 BLNK/' '/,ZERO/'0'/,MINUS/'-'/                          IRD00130
      DATA LL/256/                                                      IRD00140
      INTEGER*4   RVAL,SIGN,IFN,FRAC                                    IRD00150
      INTEGER*4 IRDR$,VAL,IDEV                                          IRD00160
      IF(IPRT.GE.20)WRITE(6,200)IDEV                                    IRD00170
200   FORMAT(' TRACE IRDR$ ',I5)                                        IRD00180
C                                                                       IRD00190
C                                                                       IRD00200
C                                                                       IRD00210
C                                                                       IRD00220
      IF(IN$(A$,LA,IDEV))6000,12,12                                     IRD00230
C                                                                       IRD00240
C                                                                       IRD00250
12    SIGN=1                                                            IRD00260
      IFN=0                                                             IRD00270
   15 DO 1 II=1,LA                                                      IRD00280
      IF(IPRT.GE.30) WRITE(6,213)A$(II)                                 IRD00290
213   FORMAT(' EXAMINING ',A1,' FOR INTEGER VALUE')                     IRD00300
      IF(A$(II).EQ.MINUS)GO TO 10                                       IRD00310
      IF(A$(II).EQ.BLNK)GOTO 1                                          IRD00320
   20 ITEMP=A$(II)-ZERO                                                 IRD00330
      ITEMP=ITEMP/LL                                                    IRD00340
      IF((ITEMP.GT.9).OR.(ITEMP.LT.0))GOTO 6007                         IRD00350
      IF(IPRT.GE.30) WRITE(6,216) ITEMP                                 IRD00360
216   FORMAT(' FOUND NUMERIC DIGIT',I2)                                 IRD00370
      IFN=IFN*10+ITEMP                                                  IRD00380
      GO TO 1                                                           IRD00390
   10 SIGN=-1                                                           IRD00400
      IF(IPRT.GE.30)WRITE(6,214)                                        IRD00410
214   FORMAT(' FOUND MINUS SIGN')                                       IRD00420
    1 CONTINUE                                                          IRD00430
217   FORMAT(' SUBROUTINE IRDR$ RETURNING VALUE ',I20)                  IRD00440
      IF(IPRT.GE.30)WRITE(6,2225) IFN ,SIGN                             IRD00450
2225  FORMAT(' SET FINAL SIGN OF',I20,' WITH',I20)                      IRD00460
                                                                        IRD00470
  660 IRDR$=SIGN*IFN                                                    IRD00480
```

AD-A110 073 NAVAL POSTGRADUATE SCHOOL MONTEREY CA F/G 9/2
A CROSS COMPILER AND PROGRAMMING SUPPORT SYSTEM FOR THE HP41CV --ETC(U)
SEP 81 J N RICHMANN

UNCLASSIFIED NL




1.0
1.1
1.25
1.4
1.6
2.0
1.8
2.2

```
      VAL=IRDR$                                                          IRD00490
      IF(IPRT.GE.20)WRITE(6,217) VAL                                     IRD00500
      RETURN                                                             IRD00510
C                                                                        IRD00520
CC                                                                       IRD00530
CC    ERROR HANDLING SECTION FOLLOWS                                     IRD00540
C                                                                        IRD00550
6000  WRITE(6,6001)                                                      IRD00560
6001  FORMAT(' *** END OF FILE DETECTED *** ',A4)                        IRD00570
      IRDR$=-1                                                           IRD00580
      STOP                                                               IRD00590
6007  WRITE(6,6008)(A$(I),I=1,LA)                                        IRD00600
6008  FORMAT(' *** ATTEMPT TO FIND INTG VALUE OF ALPHABETIC STRING:'/    IRD00610
     2       ' ',110A1)                                                  IRD00620
      STOP                                                               IRD00630
      END                                                                IRD00640
```

```
      INTEGER FUNCTION ITWO$(A$,LA,M,M1,INDIR)                          ITW00010
C*****************************************************************    *ITW00020
C**                                                                   **ITW00030
C**    STRING A$  IS A POSTFIX FOR A MULTI-WORD INSTRUCTICN.          **ITW00040
C**                                                                   **ITW00050
C**    THIS ROUTINE WILL EXAMINE THE POSTFIX AND RETURN A DECIMAL     **ITW00060
C**    VALUE INTERPRETATION OF THE POSTFIX.                           **ITW00070
C**                                                                   **ITW00080
C**    INDIRECT INSTRUCTIONS WILL HAVE THE POSTFIX APPROPRIATELY      **ITW00090
C**    SET WITH THE HIGH ORDER BIT ON, AS REQUIRED BY THE INDIR FLAG  **ITW00100
C**                                                                   **ITW00110
C**                                                                   **ITW00120
C**    THE RETURN VALUE OF THE FUNCTION ITWO$ IS SET AS FOLLOWS:      **ITW00130
C**          0  =  CONTINUE TO COMPILE                                **ITW00140
C**         -1  =  AN ERROR IN COMPILING THE INSTRUCTION.             **ITW00150
C**                                                                   **ITW00160
C**                                                                   **ITW00170
C*****************************************************************    *ITW00180
      IMPLICIT INTEGER(A-Z)                                             ITW00190
      COMMON/TEXT/IDIM,IPR(1                                            ITW00200
      INTEGER*2 A$(IDIM)                                                ITW00210
      INTEGER*2 BLNK/' '/                                               ITW00220
      INTEGER*2 LABEL(26)/'A','B','C','D','E','F','G','H','I','J',     ITW00230
     2                    'T','Z','Y','X','L',' ',' ',' ',' ',' ',     ITW00240
     3                    ' ',' ',' ',' ',' ',' ',' ',' '/             ITW00250
      INTEGER*4 FUNC$/'ITWO'/                                           ITW00260
      INTEGER*4 M(1)                                                    ITW00270
      LOGICAL INDIR                                                     ITW00280
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                      ITW00290
200   FORMAT(' TRACE ',I3,' ITWO$    :  ',110A1)                        ITW00300
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                               ITW00310
C                                                                       ITW00320
C                                                                       ITW00330
C                                                                       ITW00340
C     CHECK FOR BLANK INDICATING A BOGUS THIRD OPERAND                  ITW00350
C                                                                       ITW00360
      IF(TRIM$(A$,LA)) 6015,6030,10                                     ITW00370
10    IF(POS$(A$,LA,BLNK,1,1)) 6015,20,6020                             ITW00380
C                                                                       ITW00390
C                                                                       ITW00400
C                                                                       ITW00410
C     CHECK FOR NUMERIC OPERAND                                         ITW00420
C                                                                       ITW00430
20    IF(NUMC$(A$,LA,IANSW)) 6015,25,50                                 ITW00440
C                                                                       ITW00450
C                                                                       ITW00460
C                                                                       ITW00470
C                                                                       ITW00480
```

```
C                                                                       ITW00490
C     OPERAND MUST BE REGISTER X,Y,Z,T OR L  OR A LOCAL ALPHA LABEL     ITW00500
C                                                                       ITW00510
25       DO 30 I=1,26                                                   ITW00520
            INDEX=I                                                     ITW00530
            IF(A$(1).EQ.LABEL(I)) GOTO 35                               ITW00540
30       CONTINUE                                                       ITW00550
C                                                                       ITW00560
C        WILL FALL THROUGH TO THIS CODE IF NO VALID LABEL FOUND         ITW00570
         GOTO 6015                                                      ITW00580
C                                                                       ITW00590
C                                                                       ITW00600
C                                                                       ITW00610
C     HAVE FOUND A MATCH IN LOCAL LABEL TABLE, SET VALUE OF SECOND OPER-ITW00620
C     AND.  THEN GOTO PROCESS SECTION TO ACTUALLY LOAD BYTE.            ITW00630
C                                                                       ITW00640
35       INDEX=INDEX+101                                                ITW00650
         GOTO 75                                                        ITW00660
C                                                                       ITW00670
C                                                                       ITW00680
C                                                                       ITW00690
C                                                                       ITW00700
C                                                                       ITW00710
C     OPERAND  MUST BE A NUMERIC LOCAL LABEL                            ITW00720
C                                                                       ITW00730
50       IF(IVAL$(A$,LA,INDEX))6015,75,75                               ITW00740
C                                                                       ITW00750
C                                                                       ITW00760
C                                                                       ITW00770
C     HAVE FOUND VALID POSTFIX, CHECK FOR INDIRECT INSTRUCTION          ITW00780
C                                                                       ITW00790
75       IF(INDIR) INDEX=INDEX+128                                      ITW00800
C                                                                       ITW00810
C                                                                       ITW00820
C                                                                       ITW00830
C     LOAD THE SECOND OPERAND IN THE MACHINE CODE ARRAY                 ITW00840
C                                                                       ITW00850
95       M(M1)=INDEX                                                    ITW00860
         IF(IPRT.GE.10)WRITE(6,212)M1,M(M1)                             ITW00870
212      FORMAT(' ITWO$',I5,'      2D OPERAND     ',T75,I3)             ITW00880
         M1=M1+1                                                        ITW00890
C                                                                       ITW00900
C                                                                       ITW00910
C                                                                       ITW00920
C     CLEAN-UP AND RETURN                                               ITW00930
C                                                                       ITW00940
         INDIR=.FALSE.                                                  ITW00950
         ITWO$=0                                                        ITW00960
```

```
      RETURN                                                                ITW00970
C                                                                           ITW00980
CC                                                                          ITW00990
CC                                                                          ITW01000
C     ERROR HANDLING SECTION FOLLOWS                                        ITW01010
C                                                                           ITW01020
6000  WRITE(6,6001) FUNC$                                                   ITW01030
6001  FORMAT(' *** STRING LENGTH ERROR *** ',A4)                            ITW01040
      WRITE(6,6010) LA,LB,IDIM                                              ITW01050
6010  FORMAT(' LA=',I10,'     LB=',I10,'     IDIM=',I10)                    ITW01060
      ITWO$=-1                                                              ITW01070
      RETURN                                                                ITW01080
6015  WRITE(6,6016)                                                         ITW01090
6016  FORMAT(' **** INVALID SECOND OPERAND IN  INSTR ****')                 ITW01100
      ITWO$=-1                                                              ITW01110
      RETURN                                                                ITW01120
6020  WRITE(6,6021)                                                         ITW01130
6021  FORMAT(' **** FOUND THREE OPERANDS, EXPECTING IND ****')              ITW01140
      ITWO$=-1                                                              ITW01150
      RETURN                                                                ITW01160
6030  WRITE(6,6031)                                                         ITW01170
6031  FORMAT(' ***** FOUND SECOND OPERAND BLANK *******')                   ITW01180
      ITWO$=-1                                                              ITW01190
      RETURN                                                                ITW01200
      END                                                                   ITW01210
```

```
      INTEGER FUNCTION IVAL$(A$,LA,VAL)                                 IVA00010
C*************************************************************************IVA00020
C**                                                                     **IVA00030
C**    CONVERTS A NUMERIC TEXT STRING TO INTEGER NUMERIC VALUE.         **IVA00040
C**                                                                     **IVA00050
C**                                                                     **IVA00060
C**                                                                     **IVA00070
C**                                                                     **IVA00080
C*************************************************************************IVA00090
      IMPLICIT INTEGER(A-Z)                                             IVA00100
      COMMON/TEXT/IDIM,IPRT                                             IVA00110
      INTEGER*2 A$(IDIM)                                                IVA00120
      INTEGER*2 BLNK/' '/,ZERO/'0'/,MINUS/'-'/                          IVA00130
      INTEGER*4 FUNC$/'VAL'/                                            IVA00140
      DATA LL/256/                                                      IVA00150
      INTEGER*4    RVAL,SIGN,IFN,FRAC                                   IVA00160
      INTEGER*4 IVAL$,VAL                                               IVA00170
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                      IVA00180
200   FORMAT(' TRACE ',I3,' IVAL$    :  ',110A1)                        IVA00190
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                               IVA00200
C                                                                       IVA00210
CCCCC                                                                   IVA00220
CCCCC                                                                   IVA00230
CCCCC                                                                   IVA00240
CCCCC                                                                   IVA00250
C                                                                       IVA00260
      SIGN=1                                                            IVA00270
      IFN=0                                                             IVA00280
   15 DO 1 II=1,LA                                                      IVA00290
         IF(IPRT.GE.30) WRITE(6,213)A$(II)                              IVA00300
213      FORMAT(' EXAMINING ',A1,' FOR INTEGER VALUE')                  IVA00310
         IF(A$(II).EQ.MINUS)GO TO 10                                    IVA00320
         IF(A$(II).EQ.BLNK)GOTO 1                                       IVA00330
   20    ITEMP=A$(II)-ZERO                                              IVA00340
         ITEMP=ITEMP/LL                                                 IVA00350
         IF((ITEMP.GT.9).OR.(ITEMP.LT.0))GOTO 6007                      IVA00360
         IF(IPRT.GE.30) WRITE(6,216) ITEMP                              IVA00370
216      FORMAT(' FOUND NUMERIC DIGIT',I2)                              IVA00380
         IFN=IFN*10+ITEMP                                               IVA00390
         GO TO 1                                                        IVA00400
   10    SIGN=-1                                                        IVA00410
         IF(IPRT.GE.30)WRITE(6,214)                                     IVA00420
214      FORMAT(' FOUND MINUS SIGN')                                    IVA00430
    1    CONTINUE                                                       IVA00440
217   FORMAT(' SUBROUTINE IVAL$ RETURNING VALUE ',I20)                  IVA00450
      IF(IPRT.GE.30)WRITE(6,2225) IFN ,SIGN                             IVA00460
2225  FORMAT(' SET FINAL SIGN OF',I20,' WITH',I20)                      IVA00470
                                                                        IVA00480
```

```
  660 IVAL$=SIGN*IFN                                                    IVA00490
      VAL=IVAL$                                                         IVA00500
      IF(IPRT.GE.20)WRITE(6,217) VAL                                    IVA00510
      RETURN                                                            IVA00520
C                                                                       IVA00530
C                                                                       IVA00540
C     ERROR HANDLING SECTION FOLLOWS                                    IVA00550
C                                                                       IVA00560
6000  WRITE(6,6001) FUNC$                                               IVA00570
6001  FORMAT(' *** STRING LENGTH ERROR *** ',A4)                        IVA00580
      IVAL$=-1                                                          IVA00590
      STOP                                                              IVA00600
6007  WRITE(6,6008)(A$(I),I=1,LA)                                       IVA00610
6008  FORMAT(' *** ATTEMPT TO FIND REAL VALUE OF ALPHABETIC STRING:'/   IVA00620
     2       ' ',110A1)                                                 IVA00630
      STOP                                                              IVA00640
      END                                                               IVA00650
```

```
      INTEGER FUNCTION LBL$(A$,LA,M,M1)                                 LBL00010
C*****************************************************************LBL00020
C**                                                               **LBL00030
C**    STRING A$ HAS BEEN IDENTIFIED TO CONTAIN AN LBL INSTRUCTION.  **LBL00040
C**                                                               **LBL00050
C**    THE RETURN VALUE OF THE FUNCTION LBL$  IS SET AS FOLLOWS:     **LBL00060
C**          0   =  CONTINUE TO COMPILE                          **LBL00070
C**         -1   =  AN ERROR IN COMPILING THE INSTRUCTION.        **LBL00080
C**                                                               **LBL00090
C**                                                               **LBL00100
C*****************************************************************LBL00110
      IMPLICIT INTEGER(A-Z)                                             LBL00120
      COMMON/TEXT/IDIM,IPRT                                             LBL00130
      COMMON/FLAGS/DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2     LBL00140
      COMMON/CNTR/P1,P2,P3,P4,P5,P6,P7,P8,P9,S1,S2                      LBL00150
      LOGICAL DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2          LBL00160
      INTEGER*4 P1,P2,P3,P4,P5,P6,P7,P8,P9,S1,S2                        LBL00170
      INTEGER*2 A$(IDIM)                                                LBL00180
      INTEGER*2 SS1$(20)                                                LBL00190
      INTEGER*4 LSS1                                                    LBL00200
C     INTEGER*2 BLNK/' '/                                               LBL00210
      INTEGER*2 QUOTE/'"'/                                              LBL00220
      INTEGER*2 LABEL(26)/'A','B','C','D','E','F','G','H','I','J',     LBL00230
     2                    'K','L','M','N','O','P','Q','R','S','T',     LBL00240
     3                    'U','V','W','X','Y','Z'/                      LBL00250
      INTEGER*4 FUNC$/'LBL'/                                            LBL00260
      INTEGER*4 M(1)                                                    LBL00270
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                      LBL00280
200   FORMAT(' TRACE ',I3,' LBL$    :  ',110A1)                         LBL00290
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                               LBL00300
C                                                                       LBL00310
CCC                                                                     LBL00320
CCC                                                                     LBL00330
CC    STRIP STRING OF "LBL" CHARACTERS.                                 LBL00340
C                                                                       LBL00350
         CALL LCUT$(A$,LA,3)                                            LBL00360
         IF(TRIM$(A$,LA)) 6015,6015,10                                  LBL00370
C                                                                       LBL00380
CCC                                                                     LBL00390
CCC                                                                     LBL00400
CC    CHECK FOR ALPHANUMERIC VERSUS LOCAL LABELS                        LBL00410
CCC                                                                     LBL00420
10       IF(A$(1).EQ.QUOTE) GOTO 80                                     LBL00430
C                                                                       LBL00440
CCC                                                                     LBL00450
CCC                                                                     LBL00460
CC    PROCESS LOCAL LABELS, FIRST CHECK FOR NUMERIC OR SINGLE CHAR ALPHALBL00470
C                                                                       LBL00480
```

```
20      IF(LA-2) 25,50,6015                                                  LBL00490
C                                                                            LBL00500
CCCCC                                                                        LBL00510
CCCCC                                                                        LBL00520
CCCCC   LENGTH OPERAND IMPLIES SINGLE CHARACTER ALPHA LOCAL LABEL            LBL00530
CCCCC                                                                        LBL00540
25      DO 30 I=1,26                                                         LBL00550
            INDEX=I                                                          LBL00560
            IF(A$(I).EQ.LABEL(I)) GOTO 35                                    LBL00570
30      CONTINUE                                                             LBL00580
C                                                                            LBL00590
C       WILL FALL THROUGH TO THIS CODE IF NO VALID LABEL FOUND               LBL00600
        GOTO 6015                                                            LBL00610
C                                                                            LBL00620
CCCCC                                                                        LBL00630
CCCCC                                                                        LBL00640
CCCCC   HAVE FOUND A MATCH IN LOCAL LABEL TABLE, SET VALUE OF SECOND OPER-   LBL00650
CCCCC   AND.  THEN GOTO PROCESS A TWO BYTE INSTRUCTION.                      LBL00660
CCCCC                                                                        LBL00670
35      INDEX=INDEX+101                                                      LBL00680
C                                                                            LBL00690
CCCCC                                                                        LBL00700
CCCCC                                                                        LBL00710
CCCCC   PROCESS A TWO BYTE INSTRUCTION                                       LBL00720
C                                                                            LBL00730
40      IBYTE=2                                                              LBL00740
        M(M1)=IBYTE                                                          LBL00750
        IF(IPRT.GE.20)WRITE(6,210)M1,IBYTE                                   LBL00760
210     FORMAT('  LBL$',I5,' LENGTH OF NEXT INSTR IS',I3)                    LBL00770
        M1=M1+1                                                              LBL00780
C                                                                            LBL00790
CCCCC                                                                        LBL00800
CCCCC                                                                        LBL00810
CCCCC   LOAD TWO BYTE LBL INSTR (EITHER SINGLE CHAR ALPHA OR 2 DIGIT NUM)    LBL00820
C                                                                            LBL00830
        M(M1)=207                                                            LBL00840
        IF(IPRT.GE.10)WRITE(6,211)M1,M(M1)                                   LBL00850
211     FORMAT('  LBL$',I5,' TWO BYTE LBL INSTR',T75,I3)                     LBL00860
        M1=M1+1                                                              LBL00870
        M(M1)=INDEX                                                          LBL00880
        IF(IPRT.GE.10)WRITE(6,212)M1,M(M1)                                   LBL00890
212     FORMAT('  LBL$',I5,' LBL 2D OPERAND     ',T75,I3)                    LBL00900
        M1=M1+1                                                              LBL00910
        LBL$=0                                                               LBL00920
        RETURN                                                               LBL00930
C                                                                            LBL00940
CCC                                                                          LBL00950
C                                                                            LBL00960
```

```
C      LENGTH OF OPERAND IMPLIES MUST BE A NUMERIC LOCAL LABEL                LBL00970
C                                                                             LBL00980
50     IF(IVAL$(A$,LA,INDEX))6015,55,55                                       LBL00990
C                                                                             LBL01000
C                                                                             LBL01010
C      HAVE FOUND VALID NUMERIC LOCAL LABEL, CHECK FOR ONE BYTE INSTR         LBL01020
C                                                                             LBL01030
55        IF(INDEX.GT.14) GOTO 40                                             LBL01040
C                                                                             LBL01050
C                                                                             LBL01060
C      PROCESS A ONE BYTE INSTRUCTION, FIRST LOAD THE LENGTH OF INSTR         LBL01070
C                                                                             LBL01080
          IBYTE=1                                                             LBL01090
          M(M1)=IBYTE                                                         LBL01100
          IF(IPRT.GE.20)WRITE(6,210)M1,IBYTE                                  LBL01110
          M1=M1+1                                                             LBL01120
C                                                                             LBL01130
C                                                                             LBL01140
C      HAVE FOUND VALID NUMERIC LOCAL LABEL <15, LOAD "LBL" INSTRUCTION       LBL01150
C                                                                             LBL01160
          M(M1)=1+INDEX                                                       LBL01170
          IF(IPRT.GE.10)WRITE(6,213)M1,M(M1)                                  LBL01180
213       FORMAT('  LBL$',I5,' ONE BYTE LBL INSTR',T75,I3)                    LBL01190
          M1=M1+1                                                             LBL01200
          LBL$=0                                                              LBL01210
          RETURN                                                              LBL01220
C                                                                             LBL01230
C                                                                             LBL01240
C      PROCESS ALPHANUMERIC LABEL, FIRST LOOK FOR SECOND QUOTE                LBL01250
C                                                                             LBL01260
80        K=0                                                                 LBL01270
          P2=POS$(A$,LA,QUOTE,1,2)                                            LBL01280
          IF(P2) 6015,120,85                                                  LBL01290
C                                                                             LBL01300
C                                                                             LBL01310
C      LOOK FOR ANOTHER QUOTE                                                 LBL01320
C                                                                             LBL01330
C                                                                             LBL01340
85        PL=P2+1                                                             LBL01350
          P4=POS$(A$,LA,QUOTE,1,PL)                                           LBL01360
          IF(P4) 6015,95,90                                                   LBL01370
C                                                                             LBL01380
C                                                                             LBL01390
                                                                              LBL01400
                                                                              LBL01410
                                                                              LBL01420
                                                                              LBL01430
C                                                                             LBL01440
```

```
C                                                                       LBL01450
CCCC    FOUND ANOTHER (THIRD OR MORE) QUOTE                             LBL01460
CCCC                                                                    LBL01470
90          P2=P4                                                       LBL01480
            GOTO 85                                                     LBL01490
C                                                                       LBL01500
CCCCC                                                                   LBL01510
CCCCC                                                                   LBL01520
CCCC    CHECK AFTER LAST QUOTE FOR KEY ASSIGNMENT CODE                  LBL01530
C                                                                       LBL01540
95          LEFT=LA-P2                                                  LBL01550
            IF(LEFT) 6015,100,105                                       LBL01560
C                                                                       LBL01570
100         LA=LA-1                                                     LBL01580
            GOTO 120                                                    LBL01590
C                                                                       LBL01600
105         PSTART=P2+1                                                 LBL01610
            CALL SEG$(A$,LA,SS1$,LSS1,PSTART,LEFT)                      LBL01620
            K=IVAL$(SS1$,LSS1,NO)                                       LBL01630
            LA=LA-LEFT-1                                                LBL01640
C                                                                       LBL01650
CCCCC                                                                   LBL01660
CCCCC                                                                   LBL01670
CCCC    SET INSTRUCTION LENGTH FOR ALPHABETIC GLOBAL LABEL              LBL01680
C                                                                       LBL01690
120         LENGTH=LA-1                                                 LBL01700
            IBYTE=4+LENGTH                                              LBL01710
            M(M1)=IBYTE                                                 LBL01720
            IF(IPRT.GE.20)WRITE(6,210)M1,IBYTE                          LBL01730
            M1=M1+1                                                     LBL01740
C                                                                       LBL01750
CCCCC                                                                   LBL01760
CCCCC                                                                   LBL01770
CCCC    HAVE FOUND VALID ALPHANUMERIC  LABEL,     LOAD "LBL" INSTRUCTION LBL01780
C                                                                       LBL01790
            M(M1)=192                                                   LBL01800
            IF(IPRT.GE.10)WRITE(6,214)M1,M(M1)                          LBL01810
214         FORMAT('  LBL$',I5,' ALPHA    LBL INSTR',T75,I3)          LBL01820
            M1=M1+1                                                     LBL01830
C                                                                       LBL01840
CCCCC                                                                   LBL01850
CCCCC                                                                   LBL01860
CCCC    PROVIDE ONE NULL INSTRUCTION  TO RESERVE SPACE FOR THE LINK     LBL01870
CCCC    POINTER.  ALL ALPHANUMERIC LABEL AND END INSTRUCTIONS CONTAIN   LBL01880
CCCC    POINTERS WHICH LINK THEM ALTOGETHER INTO A LABEL CHAIN.  THIS   LBL01890
CCCC    CHAIN IS USED TO IDENTIFY THE POSITION OF LABELS AND PROGRAM    LBL01900
CCCC    BOUNDARIES WITHIN THE HP41CV MEMORY.  THE CHAIN OF LABELS IS    LBL01910
C       RECOMPILED BY THE WAND SOFTWARE, SO THE BYTES CONTAINING THE    LBL01920
```

```
C      CHAIN ARE SET TO ZERO BY THIS COMPILER.                          LBL01930
C                                                                       LBL01940
          M(M1)=0                                                       LBL01950
          IF(IPRT.GE.10)WRITE(6,215)M1,M(M1)                            LBL01960
215       FORMAT(' LBL$',I5,' TRAILNG NULL INSTR',T75,I3)               LBL01970
          M1=M1+1                                                       LBL01980
C                                                                       LBL01990
CC                                                                      LBL02000
CC                                                                      LBL02010
CC     SET INDICATOR FOR NUMBER OF ALPHA CHARS IN LABEL                 LBL02020
C                                                                       LBL02030
          M(M1)=241+LENGTH                                              LBL02040
          IF(IPRT.GE.10)WRITE(6,216)M1,M(M1)                            LBL02050
216       FORMAT(' LBL$',I5,' LENGTH CODE ALPH LBL',T75,I3)             LBL02060
          M1=M1+1                                                       LBL02070
C                                                                       LBL02080
CC                                                                      LBL02090
CC                                                                      LBL02100
CC     ENCODE KEY ASSIGNMENT                                            LBL02110
C                                                                       LBL02120
          IF(K.NE.0) GOTO 130                                           LBL02130
C              SINCE K=0 IMPLIES NULL KEY ASIGNMENT                     LBL02140
               M(M1)=0                                                  LBL02150
               IF(IPRT.GE.10)WRITE(6,217)M1,M(M1)                       LBL02160
217            FORMAT(' LBL$',I5,' NULL KEY ASSIGNMENT ',T75,I3)        LBL02170
               M1=M1+1                                                  LBL02180
               GOTO 140                                                 LBL02190
C                                                                       LBL02200
C              SINCE K¬=0 IMPLIES A KEY ASSIGNMENT TO BE MADE           LBL02210
130            K1=0                                                     LBL02220
               IF(K.GT.0) GOTO 135                                      LBL02230
               K1=8                                                     LBL02240
               K=IABS(K)                                                LBL02250
135            A1=K/10                                                  LBL02260
               B1=MOD(K,10)                                             LBL02270
               K=16*(B1-1)+A1+K1                                        LBL02280
               M(M1)=K                                                  LBL02290
               IF(IPRT.GE.10)WRITE(6,218)M1,M(M1)                       LBL02300
218            FORMAT(' LBL$',I5,' LBL  KEY ASSIGNMENT ',T75,I3)        LBL02310
               M1=M1+1                                                  LBL02320
C                                                                       LBL02330
CC                                                                      LBL02340
CC                                                                      LBL02350
CC     ADD ALPHABETIC CHARACTERS AND RETURN                             LBL02360
C                                                                       LBL02370
140       LA=LENGTH+1                                                   LBL02380
          LBL$=ALPH$(A$,LA,M,M1)                                        LBL02390
          RETURN                                                        LBL02400
```

```
C                                                                       LBL02410
CC                                                                      LBL02420
CC      ERROR HANDLING SECTION FOLLOWS                                  LBL02430
CC                                                                      LBL02440
C                                                                       LBL02450
6000    WRITE(6,6001) FUNC$                                             LBL02460
6001    FORMAT(' *** STRING LENGTH ERROR *** ',A4)                      LBL02470
        WRITE(6,6010) LA,LB,IDIM                                        LBL02480
6010    FORMAT(' LA=',I10,'     LB=',I10,'     IDIM=',I10)              LBL02490
        LBL$=-1                                                         LBL02500
        RETURN                                                          LBL02510
6015    WRITE(6,6016)                                                   LBL02520
6016    FORMAT(' ***** INVALID SECOND OPERAND IN LBL INSTR ****')       LBL02530
        LBL$=-1                                                         LBL02540
        RETURN                                                          LBL02550
        END
```

```
      INTEGER FUNCTION MEM$(A$,LA,M,M1,WHICH)                          MEM00010
C*****************************************************************MEM00020
C**                                                                 **MEM00030
C**    STRING A$ CONTAINS AN MEMORY INSTRUCTION, EITHER AN STO OR A  **MEM00040
C**    RCL                                                          **MEM00050
C**                                                                 **MEM00060
C**    THE RETURN VALUE OF THE FUNCTION MEM$ IS SET AS FOLLOWS:     ** MEM00070
C**          0   =  CONTINUE TO COMPILE                            **MEM00080
C**         -1   =  AN ERROR IN COMPILING THE INSTRUCTION.          **MEM00090
C**                                                                 **MEM00100
C**                                                                 **MEM00110
C*****************************************************************MEM00120
      IMPLICIT INTEGER(A-Z)                                          MEM00130
      COMMON/TEXT/IDIM,IPRT                                          MEM00140
      COMMON/FLAGS/DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2  MEM00150
      COMMON/CNTR/P1,P2,P3,P4,P5,P6,P7,P8,P9,S1,S2                   MEM00160
      LOGICAL DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2       MEM00170
      INTEGER*4 P1,P2,P3,P4,P5,P6,P7,P8,P9,S1,S2                     MEM00180
      INTEGER*2 A$(IDIM)                                             MEM00190
C     INTEGER*2 BLNK/' '/                                            MEM00200
      INTEGER*2 IND(3)/'I','N','D'/                                  MEM00210
      INTEGER*2 C$( 5)/'T','Z','Y','X','L'/                          MEM00220
      INTEGER*4 LC/ 5/                                               MEM00230
      INTEGER*4 WHICH(5)                                             MEM00240
      INTEGER*4 FUNC$/'MEM'/                                         MEM00250
      INTEGER*4 M(1)                                                 MEM00260
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                   MEM00270
200   FORMAT(' TRACE ',I3,' MEM$    :  ',110A1)                      MEM00280
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                            MEM00290
C                                                                    MEM00300
C                                                                    MEM00310
C                                                                    MEM00320
C     STRIP STRING OF "MEM" CHARACTERS.                              MEM00330
C                                                                    MEM00340
      IF(LCUT$(A$,LA,3)) 6015,6015,7                                 MEM00350
7     IF(TRIM$(A$,LA)) 6015,6015,10                                  MEM00360
C                                                                    MEM00370
C                                                                    MEM00380
C                                                                    MEM00390
C     ESTABLISH MOST LIKELY INSTR LENGTH AND PREFIX                  MEM00400
C                                                                    MEM00410
10    IBYTE=2                                                        MEM00420
      PREFIX=WHICH(1)                                                MEM00430
      H=WHICH(2)                                                     MEM00440
C                                                                    MEM00450
C                                                                    MEM00460
C     CHECK FOR INDIRECT ADDRESS                                     MEM00470
C                                                                    MEM00480
```

```
C                                                                       MEM00490
20        P6=POS$(A$,LA,IND,3,1)                                        MEM00500
          IF(P6) 6000,40,21                                             MEM00510
21              INDIR=.TRUE.                                            MEM00520
                IF(LCUT$(A$,LA,3)) 6000,6015,22                         MEM00530
22              IF(TRIM$(A$,LA)) 6015,6015,40                           MEM00540
CCCCC                                                                   MEM00550
CCCCC                                                                   MEM00560
CCCCC                                                                   MEM00570
CCCCC     CHECK FOR NUMERIC SECCND OPERAND                              MEM00580
CCCCC                                                                   MEM00590
40        IF(NUMC$(A$,LA,IANSW)) 6015,45,60                             MEM00600
CCCCC                                                                   MEM00610
CCCCC                                                                   MEM00620
CCCCC                                                                   MEM00630
CCCCC     PROCESS NON-NUMERIC SECOND OPERAND                            MEM00640
CCCCC                                                                   MEM00650
45              IF(LA.GT.1) GOTO 6015                                   MEM00660
                IZ=FIND$(A$(1),LA,C$,LC,LCC)                            MEM00670
                IF(IZ.NE.0)GOTO 46                                      MEM00680
                     WRITE(6,207)A$(1)                                  MEM00690
207                  FORMAT(' ***** INVALID CHARACTER     *****',5X,A1) MEM00700
                     MEM$=-1                                            MEM00710
                     RETURN                                             MEM00720
46              POSTFX=IZ+111                                           MEM00730
                GOTO 100                                                MEM00740
CCCCC                                                                   MEM00750
CCCCC                                                                   MEM00760
CCCCC                                                                   MEM00770
CCCCC     PROCESS NUMERIC POSTFIX OPERANDS                              MEM00780
CCCCC                                                                   MEM00790
60        POSTFX=IVAL$(A$,LA,VAL)                                       MEM00800
CCCCC                                                                   MEM00810
CCCCC                                                                   MEM00820
CCCCC                                                                   MEM00830
CCCCC     CHECK FOR ONE BYTE VERSUS TWO BYTE NUMERIC OPERANDS           MEM00840
C                                                                       MEM00850
          IF((POSTFX.GT.15).OR.(INDIR)) GOTO 75                         MEM00860
CCCCC                                                                   MEM00870
CCCCC                                                                   MEM00880
CCCCC                                                                   MEM00890
CCCCC     PROCESS ONE BYTE NUMERIC SECOND OPRANDS                       MEM00900
C                                                                       MEM00910
                IBYTE=1                                                 MEM00920
                PREFIX=POSTFX+H                                         MEM00930
                GOTO 100                                                MEM00940
C                                                                       MEM00950
CC                                                                      MEM00960
```

```
C
CCCC      PROCESS TWO BYTE NUMERIC OPERANDS                                    MEM00970
CCCC                                                                           MEM00980
C                                                                              MEM00990
75              CONTINUE                                                       MEM01000
C                                                                              MEM01010
CCCC                                                                           MEM01020
CCCC      SET THE LENGTH OF THE INSTRUCTION                                    MEM01030
CCCC                                                                           MEM01040
100       M(M1)=IBYTE                                                          MEM01050
          IF(IPRT.GE.20)WRITE(6,215)M1,IBYTE                                   MEM01060
215       FORMAT('  MEM$',I5,' LENGTH OF THIS INSTR IS',I3)                    MEM01070
          M1=M1+1                                                              MEM01080
C                                                                              MEM01090
CCCC                                                                           MEM01100
CCCC      ENCODE THE PREFIX OF THIS INSTRUCTION                                MEM01110
C                                                                              MEM01120
          M(M1)=PREFIX                                                         MEM01130
          IF(IPRT.GE.10)WRITE(6,211)M1,(WHICH(I),I=3,5),M(M1)                  MEM01140
211       FORMAT('  MEM$',I5,' ',3A1,'      INSTR',T75,I3)                     MEM01150
          M1=M1+1                                                              MEM01160
C                                                                              MEM01170
CCCC                                                                           MEM01180
CCCC      ENCODE THE POSTFIX OF THIS INSTRUCTION                               MEM01190
C                                                                              MEM01200
          IF(IBYTE.EQ.1) GOTO 125                                              MEM01210
          IF(INDIR)POSTFX=POSTFX+128                                           MEM01220
          M(M1)=POSTFX                                                         MEM01230
          IF(IPRT.GE.10)WRITE(6,221)M1,(WHICH(I),I=3,5),M(M1)                  MEM01240
221       FORMAT('  MEM$',I5,' ',3A1,' INSTR POSTFIX',T75,I3)                  MEM01250
          M1=M1+1                                                              MEM01260
C                                                                              MEM01270
CCC                                                                            MEM01280
C                                                                              MEM01290
CCC                                                                            MEM01300
C                                                                              MEM01310
CCC                                                                            MEM01320
C                                                                              MEM01330
CCC                                                                            MEM01340
C                                                                              MEM01350
125       MEM$=0                                                               MEM01360
          RETURN                                                               MEM01370
C                                                                              MEM01380
CCC       ERROR HANDLING SECTION FOLLOWS                                       MEM01390
CCC                                                                            MEM01400
6000      WRITE(6,6001) FUNC$                                                  MEM01410
6001      FORMAT(' *** STRING LENGTH ERROR *** ',A4)                           MEM01420
          WRITE(6,6010) LA,LB,IDIM                                             MEM01430
6010      FORMAT(' LA=',I10,'     LB=',I10,'     IDIM=',I10)                   MEM01440
```

```
      MEM$=-1                                                          MEM01450
      RETURN                                                           MEM01460
6015  WRITE(6,6016)                                                    MEM01470
6016  FORMAT(' ***** INVALID SECOND OPERAND IN MEM INSTR ****')        MEM01480
      MEM$=-1                                                          MEM01490
      RETURN                                                           MEM01500
      END                                                              MEM01510
```

```
      INTEGER FUNCTION NEWPG$(LINCNT,NUMPGE,TITLE$,LTITLE,MTITLE)          NEW00010
C*****************************************************************************NEW00020
C**                                                                         **NEW00030
C**     THIS SUBROUTINE IS USED TO PLACE MAKE THE OUTPUT LISTING            **NEW00040
C**     AS ATTRACTIVE AS POSSIBLE.  IT PERFORMS ALL THE HOUSEKEEPING        **NEW00050
C**     FUNCTIONS ASSOCIATED WITH GOING TO A NEW PAGE.                      **NEW00060
C**                                                                         **NEW00070
C**                                                                         **NEW00080
C**     IT SHOULD BE CALLED BY THE USE OF A STATEMENT SUCH AS               **NEW00090
C**                                                                         **NEW00100
C**          IF(MOD(LINCNT,PAGE).EQ.0)                                      **NEW00110
C**         1     CALL NEWPG$(LINCNT,PAGENUMBER,TITLE$,LTITLE,MTITLE)       **NEW00120
C**                                                                         **NEW00130
C**                                                                         **NEW00140
C*****************************************************************************NEW00150
      IMPLICIT INTEGER(A-Z)                                                 NEW00160
      COMMON/TEXT/IDIM,IPRT                                                 NEW00170
      INTEGER*2 TITLE$(LTITLE,MTITLE)                                       NEW00180
C     INTEGER*2 BLNK/' '/                                                   NEW00190
C     INTEGER*2 CARD(80)                                                    NEW00200
C     INTEGER*4 FUNC$/'NEWPG'/                                              NEW00210
297   FORMAT(//,' ')                                                        NEW00220
299   FORMAT('1',////)                                                      NEW00230
200   FORMAT(' ',116A1)                                                     NEW00240
201   FORMAT(' ',132A1)                                                     NEW00250
C                                                                           NEW00260
C                                                                           NEW00270
C                                                                           NEW00280
C     PRINT THE OUTPUT PAGE HEADING                                         NEW00290
C                                                                           NEW00300
      WRITE(6,299)                                                          NEW00310
      IF(MTITLE.LE.0) GOTO 75                                               NEW00320
      IF(LTITLE.GT.116)LTITLE=116                                           NEW00330
      WRITE(6,200)(TITLE$(JJ,1),JJ=1,LTITLE)                                NEW00340
      IF(MTITLE.EQ.1) GOTO 75                                               NEW00350
      DO 50 II = 2,MTITLE                                                   NEW00360
         WRITE(6,201)(TITLE$(JJ,II),JJ=1,LTITLE)                            NEW00370
50    CONTINUE                                                              NEW00380
C                                                                           NEW00390
C                                                                           NEW00400
C                                                                           NEW00410
C     UPDATE THE PAGE COUNTER AND RESET THE LINE COUNTER                    NEW00420
C                                                                           NEW00430
75    NUMPGE=NUMPGE+1                                                       NEW00440
      LINCNT=MTITLE                                                         NEW00450
      WRITE(6,297)                                                          NEW00460
C                                                                           NEW00470
C                                                                           NEW00480
```

```
C       EXIT                                                            NEW00490
C                                                                       NEW00500
        NEWPG$=NUMPGE                                                   NEW00510
        RETURN                                                          NEW00520
C                                                                       NEW00530
CC                                                                      NEW00540
CCC                                                                     NEW00550
CC      ERROR HANDLING SECTION FOLLOWS                                  NEW00560
C                                                                       NEW00570
6000    WRITE(6,6001) FUNC$                                             NEW00580
6001    FORMAT(' *** PAGE OUTPUT    ERROR *** ',A4)                     NEW00590
        NEWPG$=-1                                                       NEW00600
        RETURN                                                          NEW00610
        END                                                             NEW00620
```

```
      INTEGER FUNCTION NUMC$(A$,LA,IANSW)                                NUM00010
C*****************************************************************NUM00020
C**                                                                 **NUM00030
C**    THIS FUNCTION CHECKS TO SEE IF A STRING IS ALL NUMERIC.      **NUM00040
C**                                                                 **NUM00050
C**    NUMERIC IS DEFINED TO MEAN ALL DIGITS,"+",'-','.','E',OR BLNK **NUM00060
C**                                                                 **NUM00070
C**    THE RETURNED VALUE OF THE INSTRUCTION IS 0 IF NOT NUMERIC    **NUM00080
C**                                             1 IF NUMERIC        **NUM00090
C**                                            -1 IF ERROR ENCOUNTERED **NUM00100
C**                                                                 **NUM00110
C**                                                                 **NUM00120
C**                                                                 **NUM00130
C*****************************************************************NUM00140
      IMPLICIT INTEGER(A-Z)                                          NUM00150
      COMMON/TEXT/IDIM,IPRT                                          NUM00160
      INTEGER*2 A$(IDIM)                                             NUM00170
      INTEGER*4 FUNC$/'NUMC'/                                        NUM00180
      INTEGER*2 DIGIT(15)/'0','1','2','3','4','5','6','7','8','9',  NUM00190
     2                    ' ','.','-','+','E'/                       NUM00200
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                   NUM00210
200   FORMAT(' TRACE ',I3,' NUMC$    :  ',110A1)                     NUM00220
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                            NUM00230
C                                                                    NUM00240
CC                                                                   NUM00250
C                                                                    NUM00260
      DO 10 I=1,LA                                                   NUM00270
         IF(LA.NE.1) GOTO 3                                          NUM00280
C              NOT ALLOWED TO EXAMINE LAST 5 CHARS IF LA IS ONE.     NUM00290
               LOOK=10                                               NUM00300
               GOTO 4                                                NUM00310
3        LOOK=15                                                     NUM00320
4        DO 5 J=1,LOOK                                               NUM00330
            IF(A$(I).EQ.DIGIT(J)) GOTO 10                            NUM00340
5        CONTINUE                                                    NUM00350
C                                                                    NUM00360
C              HAVE FOUND A NON-NUMERIC CHARACTER                    NUM00370
7              IANSW=0                                               NUM00380
               NUMC$=0                                               NUM00390
               IF(IPRT.GE.20) WRITE(6,201)                           NUM00400
201            FORMAT(' STRING DETERMINED TO BE NON-NUMERIC')        NUM00410
               RETURN                                                NUM00420
C                                                                    NUM00430
C        CHARACTER FOUND TO BE NUMERIC,TAKE NEXT CHARACTER           NUM00440
10       CONTINUE                                                    NUM00450
C                                                                    NUM00460
C                                                                    NUM00470
C     IF YOU GET TO HERE THE STRING MUST BE ALL NUMERIC.             NUM00480
```

```
      IANSW=1                                                          NUM00490
      NUMC$=1                                                          NUM00500
      IF(IPRT.GE.20) WRITE(6,202)                                      NUM00510
  202 FORMAT(' STRING FOUND TO BE NUMERIC')                            NUM00520
      RETURN                                                           NUM00530
C                                                                      NUM00540
CCCCC ERROR HANDLING SECTION FOLLOWS                                   NUM00550
C                                                                      NUM00560
 6000 WRITE(6,6001) FUNC$                                              NUM00570
 6001 FORMAT(' *** STRING LENGTH ERROR *** ',A4)                       NUM00580
      WRITE(6,6010) LA,LB,IDIM                                         NUM00590
 6010 FORMAT(' LA=',I10,'     LB=',I10,'     IDIM=',I10)               NUM00600
      NUMC$=-1                                                         NUM00610
      RETURN                                                           NUM00620
      END                                                              NUM00630
                                                                       NUM00640
                                                                       NUM00650
```

```
      INTEGER FUNCTION PARS$(A$,LA,B$,LB)                                PAR00010
C*****************************************************************PAR00020
C**                                                                 **PAR00030
C**     STRING A$ IS SEARCHED FOR THE OCCURANCE OF THE 1ST NON-LEADING **PAR00040
C**     BLANK.  THEN A$ IS SPLIT INTO TWO SUBSTRINGS, THE LEADING   **PAR00050
C**     TOKEN (FIRST WORD) IS PLACED IN B$ AND THE REMAINDER IS PLACED **PAR00060
C**     IN A$.                                                      **PAR00070
C**                                                                 **PAR00080
C**     THE NUMBER OF NON-BLANK CHARACTERS REMAINING IN A$ AFTER THE **PAR00090
C**     REMOVAL OF THE FIRST WORD IS RETURNED AS THE FUNCTION VALUE **PAR00100
C**     POS$.                                                       **PAR00110
C**                                                                 **PAR00120
C**     AN ATTEMPT TO PARSE A NULL STRING WILL RESULT IN A SPECIAL  **PAR00130
C**     CHARACTER BEING PLACED IN THE 1ST POSITION OF A$.  A SUBSEQUENT**PAR00140
C**     ATTEMPT TO REPARSE THIS STRING WILL RESULT IN A FATAL ERROR. **PAR00150
C**     THIS FEATURE IS INTENDED TO PREVENT UNCONTROLLED LOOPING OF THE**PAR00160
C**     PARSE FUNCTION ON A NULL STRING.  THE SPECIAL CHARACTER USED **PAR00170
C**     IS KNOWN ONLY TO THIS ROUTINE AND MAY BE USED AS A REGULAR  **PAR00180
C**     CHARACTER FOR IN ANY STRING OF LENGTH GREATER THAN ZERO.     **PAR00190
C**                                                                 **PAR00200
C*****************************************************************PAR00210
      IMPLICIT INTEGER(A-Z)                                          PAR00220
      COMMON/TEXT/IDIM,IPRT                                          PAR00230
      INTEGER*2 A$(IDIM),B$(IDIM)                                    PAR00240
      INTEGER*2 BLNK/' '/                                            PAR00250
      INTEGER*2 HALT/' '/                                            PAR00260
      INTEGER*4 FUNC$/'PARS'/                                        PAR00270
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                   PAR00280
200   FORMAT(' TRACE ',I3,' PARS$    :  ',110A1)                     PAR00290
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                            PAR00300
C                                                                    PAR00310
CCC                                                                  PAR00320
C                                                                    PAR00330
C     CHECK TO SEE IF INPUT STRING IS NULL                           PAR00340
C                                                                    PAR00350
      IF(LA.NE.0) GOTO 5                                             PAR00360
         IF(IPRT.GE.20) WRITE(6,204)                                 PAR00370
204      FORMAT(' ATTEMPTED TO PARSE A NULL STRING.')                PAR00380
         IF(A$(1).EQ.HALT) GOTO 6005                                 PAR00390
         A$(1)=HALT                                                  PAR00400
         PARS$=0                                                     PAR00410
         LB=0                                                        PAR00420
         RETURN                                                      PAR00430
C                                                                    PAR00440
CCC                                                                  PAR00450
C                                                                    PAR00460
C     TRIM THE INPUT STRING OF LEADING BLANKS                        PAR00470
C                                                                    PAR00480
```

```
5       IM=0                                                                    PAR00490
        DO 10 I=1,LA                                                            PAR00500
           IF(A$(I).NE.BLNK) GOTO 15                                            PAR00510
           IM=IM+1                                                              PAR00520
10      CONTINUE                                                                PAR00530
15      IF(IM.EQ.0) GOTO 25                                                     PAR00540
           IF(IPRT.GE.20) WRITE(6,201) IM                                       PAR00550
201        FORMAT(' FOUND',I3,' LEADING BLANKS IN INPUT STRING')                PAR00560
           IF(IM.LT.LA) GOTO 20                                                 PAR00570
                LA=0                                                            PAR00580
                LB=0                                                            PAR00590
                PARS$=0                                                         PAR00600
                IF(IPRT.GE.20) WRITE(6,202)                                     PAR00610
202             FORMAT(' FOUND INPUT STRING IS ALL BLANKS')                     PAR00620
                RETURN                                                          PAR00630
20         LEFT=LA-IM                                                           PAR00640
           DO 23 I=1,LEFT                                                       PAR00650
              A$(I)=A$(I+IM)                                                    PAR00660
23         CONTINUE                                                             PAR00670
           LA=LEFT                                                              PAR00680
C                                                                               PAR00690
C                                                                               PAR00700
C                                                                               PAR00710
C       LOCATE THE FIRST NON-LEADING BLANK IN A$  (THEREBY DETERMINE LB)        PAR00720
C                                                                               PAR00730
25      LB=0                                                                    PAR00740
        DO 30 I=1,LA                                                            PAR00750
           IF(A$(I).EQ.BLNK) GOTO 35                                            PAR00760
           LB=LB+1                                                              PAR00770
30      CONTINUE                                                                PAR00780
C                                                                               PAR00790
C                                                                               PAR00800
C       CONSTRUCT TOKEN                                                         PAR00810
C                                                                               PAR00820
35      DO 45 I=1,LB                                                            PAR00830
           B$(I)=A$(I)                                                          PAR00840
45      CONTINUE                                                                PAR00850
        IF(IPRT.GE.20) WRITE(6,205) LB,(B$(I),I=1,LB)                           PAR00860
205     FORMAT(' PARS$ FOUND TOKEN',I3,' "',60A1)                               PAR00870
C                                                                               PAR00880
C                                                                               PAR00890
C       REMOVE TOKEN FROM FRONT OF INPUT STRING                                 PAR00900
C                                                                               PAR00910
        LEFT=LA-LB-1                                                            PAR00920
        IF(LEFT.GT.0) GOTO 50                                                   PAR00930
           LA=0                                                                 PAR00940
           GOTO 75                                                              PAR00950
50      DO 55 I=1,LEFT                                                          PAR00960
```

```
            A$(I)=A$(I+LB+1)                                                    PAR00970
55          CONTINUE                                                            PAR00980
            LA=LEFT                                                             PAR00990
C                                                                               PAR01000
C                                                                               PAR01010
C           CHECK $A FOR TRAILING BLANKS                                        PAR01020
C                                                                               PAR01030
            IF(LA.EQ.0) GOTO 75                                                 PAR01040
58          IM=0                                                                PAR01050
            DO 60 I=1,LA                                                        PAR01060
               INDEX=LA-I+1                                                     PAR01070
               IF(A$(INDEX).NE.BLNK) GOTO 65                                    PAR01080
               IM=IM+1                                                          PAR01090
60          CONTINUE                                                            PAR01100
65          IF(IM.EQ.0) GOTO 75                                                 PAR01110
               IF(IPRT.GE.20) WRITE(6,207) IM                                   PAR01120
207            FORMAT(' FOUND',I3,' TRAILING BLANKS IN INPUT STRING')           PAR01130
               IF(IM.LT.LA) GOTO 70                                             PAR01140
                    LA=0                                                        PAR01150
                    PARS$=0                                                     PAR01160
                    IF(IPRT.GE.20) WRITE(6,208)                                 PAR01170
208                 FORMAT(' FOUND REMAINING STRING IS ALL BLANKS')             PAR01180
                    RETURN                                                      PAR01190
70          LA=LA-IM                                                            PAR01200
75          PARS$=LA                                                            PAR01210
            IF(IPRT.GE.20.AND.LA.EQ.0) WRITE(6,209)                             PAR01220
209         FORMAT(' REMAINING STRING AFTER PARSE FUNCTION IS NULL')            PAR01230
            RETURN                                                              PAR01240
C                                                                               PAR01250
C                                                                               PAR01260
C                                                                               PAR01270
C           ERROR HANDLING SECTION FOLLOWS                                      PAR01280
C                                                                               PAR01290
6000        WRITE(6,6001) FUNC$                                                 PAR01300
6001        FORMAT(' *** STRING LENGTH ERROR *** ',A4)                          PAR01310
            PARS$=-1                                                            PAR01320
            RETURN                                                              PAR01330
6005        WRITE(6,6006)                                                       PAR01340
6006        FORMAT(' *** FATAL ERROR: ATTEMPTED TO PARSE A NULL STRING TWICE')  PAR01350
            STOP                                                                PAR01360
            END                                                                 PAR01370
```

```
      INTEGER FUNCTION POS$(A$,LA,B$,LB,LSTART)                          POS00010
C*****************************************************************POS00020
C**                                                                 **POS00030
C**     THE STRING A$ IS SEARCHED FOR THE OCCURANCE OF THE SUBSTRING  **POS00040
C**     B$, AND THE POSITION OF THE 1ST CHARACTER OF A$ WHERE B$ IS   **POS00050
C**     A MATCH IS ASSIGNED TO POS$.  THE SEARCH BEGINS AT LSTART     **POS00060
C**     IN A$.  A ZERO IS RETURNED IF NO MATCH IS FOUND.  A NEGATIVE  **POS00070
C**     NUMBER IS RETURNED UPON AN ERROR.                             **POS00080
C*****************************************************************POS00090
      IMPLICIT INTEGER(A-Z)                                              POS00100
      COMMON/TEXT/IDIM,IPRT                                              POS00110
      INTEGER*2 A$(IDIM),B$(IDIM)                                        POS00120
      INTEGER*4 FUNC$/'POS'/                                             POS00130
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                       POS00140
200   FORMAT(' TRACE ',I3,' POS$   :  ',110A1)                           POS00150
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                                POS00160
      IF(LB.GT.IDIM.OR.LB.LT.0) GOTO 6000                                POS00170
C                                                                        POS00180
CC                                                                       POS00190
C                                                                        POS00200
      IF(LB.LE.(LA-LSTART+1))GOTO 10                                     POS00210
         POS$=0                                                          POS00220
         IF(IPRT.GE.20) WRITE(6,201)                                     POS00230
201      FORMAT(' FIRST STRING TOO SHORT TO CONTAIN SECOND STRING')      POS00240
         RETURN                                                          POS00250
C                                                                        POS00260
C                                                                        POS00270
10    LEFT=LA-LB+1                                                       POS00280
      DO 25 I=LSTART,LEFT                                                POS00290
         DO 20 J=1,LB                                                    POS00300
               JN=I+J-1                                                  POS00310
               IF(IPRT.GE.20)WRITE(6,202)JN,A$(JN),J,B$(J)               POS00320
202            FORMAT(' COMPARE A$(',I3,')=',A1,' WITH B$(',I3,')=',A1)  POS00330
               IF(A$(JN).NE.B$(J))GOTO 25                                POS00340
20       CONTINUE                                                        POS00350
      POS$=I                                                             POS00360
      IF(IPRT.GE.20)WRITE(6,203) I                                       POS00370
203   FORMAT(' AT POSITION',I3,' SECOND STRING FOUND IN FIRST')          POS00380
      RETURN                                                             POS00390
C                                                                        POS00400
CC                                                                       POS00410
C                                                                        POS00420
25    CONTINUE                                                           POS00430
C                                                                        POS00440
C     ROUTINE WILL FALL THROUGH TO FOLLOWING IF NO MATCH FOUND.          POS00450
C                                                                        POS00460
      POS$=0                                                             POS00470
      IF(IPRT.GE.20)WRITE(6,204)                                         POS00480
```

```
204   FORMAT(' FIRST STRING SEARCHED AND SECOND STRING NOT FOUND')      POS00490
      RETURN                                                            POS00500
C                                                                       POS00510
C     ERROR HANDLING SECTION FOLLOWS                                    POS00520
C                                                                       POS00530
C                                                                       POS00540
6000  WRITE(6,6001) FUNC$                                               POS00550
6001  FORMAT(' *** STRING LENGTH ERROR *** ',A4)                        POS00560
      POS$=-1                                                           POS00570
      RETURN                                                            POS00580
      END
```

```
      INTEGER FUNCTION RCUT$(A$,LA,NUM)                                 RCU00010
C*****************************************************************    *RCU00020
C**                                                                   **RCU00030
C**    STRING A$ HAS NUM CHARACTERS REMOVED FROM THE RIGHT.           **RCU00040
C**                                                                   **RCU00050
C**    THE VALUE OF THE FUNCTION RCUT$ IS SET TO                      **RCU00060
C**            LA IF LA IS GREATER THAN 0                             **RCU00070
C**             0 IF THE NULL STRING IS LEFT AFTER THE REMOVAL        **RCU00080
C**            -1 IF AN ERROR IS ENCOUNTERED.                         **RCU00090
C**                                                                   **RCU00100
C**                                                                   **RCU00110
C**                                                                   **RCU00120
C*****************************************************************    *RCU00130
      IMPLICIT INTEGER(A-Z)                                             RCU00140
      COMMON/TEXT/IDIM,IPRT                                             RCU00150
      INTEGER*2 A$(IDIM)                                                RCU00160
      INTEGER*4 FUNC$/'RCUT'/                                           RCU00170
      INTEGER*4 NUM                                                     RCU00180
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                      RCU00190
200   FORMAT(' TRACE ',I3,' RCUT$   : ',110A1)                          RCU00200
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                               RCU00210
C                                                                       RCU00220
C                                                                       RCU00230
C                                                                       RCU00240
      LEFT=LA-NUM                                                       RCU00250
      IF((LEFT).GT.0) GOTO 20                                           RCU00260
         IF(IPRT.GE.10)WRITE(6,202)                                     RCU00270
202      FORMAT(' STRING REDUCED TO NULL STRING BY RCUT$')              RCU00280
         LA=0                                                           RCU00290
         RCUT$=0                                                        RCU00300
         RETURN                                                         RCU00310
C                                                                       RCU00320
C                                                                       RCU00330
C                                                                       RCU00340
20    CONTINUE                                                          RCU00350
      LA=LEFT                                                           RCU00360
      IF(IPRT.GE.20)WRITE(6,201)LA,(A$(I),I=1,LA)                       RCU00370
201   FORMAT(' STRING NOW',I4,' "',110A1)                               RCU00380
      RCUT$=LA                                                          RCU00390
      RETURN                                                            RCU00400
C                                                                       RCU00410
C     ERROR HANDLING SECTION FOLLOWS                                    RCU00420
C                                                                       RCU00430
6000  WRITE(6,6001) FUNC$                                               RCU00440
6001  FORMAT(' *** STRING LENGTH ERROR *** ',A4)                        RCU00450
      RCUT$=-1                                                          RCU00460
      RETURN                                                            RCU00470
      END                                                               RCU00480
```

```
      INTEGER FUNCTION SEG$(A$,LA,B$,LB,LSTART,LOUT)                    SEG00010
C*****************************************************************SEG00020
C**                                                                 **SEG00030
C**     A SUBSTRING IS EXTRACTED FROM A$ AND ASSIGNED TO B$.  THE   **SEG00040
C**     SUBSTRING IN A$ BEGINS AT POSITION LSTART AND IS LOUT CHAR- **SEG00050
C**     ACTERS LONG.                                                **SEG00060
C**                                                                 **SEG00070
C**     IF EITHER A$ IS THE NULL STRING                             **SEG00080
C**           OR A$ DOES NOT HAVE ENOUGH CHARACTERS                 **SEG00090
C**        THEN B$ IS RIGHT PADDED WITHBLANKS SO IT HAS LOUT CHAR   **SEG00100
C**                                                                 **SEG00110
C**     IF LOUT=0, THEN B$ BECOMES THE NULL STRING                  **SEG00120
C**                                                                 **SEG00130
C**     THE ACTUAL NUMBER OF NON-BLANK CHARACTERS OBTAINED FROM A$  **SEG00140
C**     IS RETURNED AS THE VALUE OF THE FUNCTION SEG$.              **SEG00150
C**                                                                 **SEG00160
C*****************************************************************SEG00170
      IMPLICIT INTEGER(A-Z)                                         SEG00180
      COMMON/TEXT/IDIM,IPRT                                         SEG00190
      INTEGER*2 A$(IDIM),B$(IDIM)                                   SEG00200
      INTEGER*2 BLNK/' '/                                           SEG00210
      INTEGER*4 FUNC$/'SEG'/                                        SEG00220
      LOGICAL FIRST                                                 SEG00230
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                  SEG00240
200   FORMAT(' TRACE ',I3,' SEG$   : ',110A1)                       SEG00250
      FIRST=.TRUE.                                                  SEG00260
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                           SEG00270
      IF(LSTART.GT.IDIM.OR.LSTART.LT.0) GOTO 6000                   SEG00280
      IF(LOUT.GT.IDIM.OR.LOUT.LT.0) GOTO 6000                       SEG00290
C                                                                   SEG00300
CC                                                                  SEG00310
C                                                                   SEG00320
      IF(LOUT.NE.0) GOTO 5                                          SEG00330
         LB=LOUT                                                    SEG00340
         IF(IPRT.GE.20) WRITE(6,202)                                SEG00350
202      FORMAT(' NULL STRING ASSIGNED BY SEG$')                    SEG00360
         SEG$=0                                                     SEG00370
         RETURN                                                     SEG00380
C                                                                   SEG00390
C                                                                   SEG00400
C                                                                   SEG00410
5     IF(LSTART.LE.LA) GOTO 15                                      SEG00420
         DO 10 I=1,LOUT                                             SEG00430
            B$(I)=BLNK                                              SEG00440
10       CONTINUE                                                   SEG00450
         LB=LOUT                                                    SEG00460
         IF(IPRT.GE.20) WRITE(6,201) LSTART,LOUT                    SEG00470
201      FORMAT(' START POINT (',I3,') GREATER THAN LENGTH FIRST STRING'SEG00480
```

```
     2              /,'    NEW STRING HAS',I3,' BLANKS')                    SEG00490
            SEG$=0                                                          SEG00500
            RETURN                                                          SEG00510
C                                                                           SEG00520
CC                                                                          SEG00530
CC                                                                          SEG00540
15          DO 35 I=1,LOUT                                                  SEG00550
            IM=I                                                            SEG00560
            IF(I.GT.(LA-LSTART+1))GOTO 25                                   SEG00570
                 B$(I)=A$(LSTART+I-1)                                       SEG00580
                 GOTO 35                                                    SEG00590
25          B$(I)=BLNK                                                      SEG00600
            IF(.NOT.FIRST) GOTO 35                                          SEG00610
                 FIRST=.FALSE.                                              SEG00620
                 SEG$=IM-1                                                  SEG00630
35          CONTINUE                                                        SEG00640
            IF(FIRST) SEG$=IM                                               SEG00650
            IF(IPRT.GE.20) WRITE(6,203) SEG$                                SEG00660
203         FORMAT(' SEG$ OBTAINED ',I3,' CHARACTERS FROM FIRST STRING')    SEG00670
            LB=LOUT                                                         SEG00680
            RETURN                                                          SEG00690
C                                                                           SEG00700
CC                                                                          SEG00710
CC                                                                          SEG00720
C           ERROR HANDLING SECTION FOLLOWS                                  SEG00730
C                                                                           SEG00740
6000        WRITE(6,6001) FUNC$                                             SEG00750
6001        FORMAT(' *** STRING LENGTH ERROR *** ',A4)                      SEG00760
            SEG$=-1                                                         SEG00770
            RETURN                                                          SEG00780
            END                                                             SEG00790
```

```
      INTEGER FUNCTION TRIM$(A$,LA)                                      TRI00010
C*****************************************************************     TRI00020
C**                                                                   **TRI00030
C**   THIS FUNCTION STRIPS A STRING OF LEADING AND TRAILING BLANKS.   **TRI00040
C**                                                                   **TRI00050
C**   THE RETURN VALUE OF THE FUNCTION IS SET TO THE LENGTH OF THE    **TRI00060
C**   STRING REMAINING AFTER THE BLANKS ARE REMOVED.                  **TRI00070
C**                                                                   **TRI00080
C*****************************************************************     TRI00090
      IMPLICIT INTEGER(A-Z)                                              TRI00100
      COMMON/TEXT/IDIM,IPRT                                              TRI00110
      INTEGER*2 A$(IDIM)                                                 TRI00120
      INTEGER*2 BLNK/' '/                                                TRI00130
      INTEGER*4 FUNC$/'TRIM'/                                            TRI00140
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                       TRI00150
200   FORMAT(' TRACE ',I3,' TRIM$    :  ',110A1)                         TRI00160
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                                TRI00170
C                                                                        TRI00180
C                                                                        TRI00190
C                                                                        TRI00200
C                                                                        TRI00210
C     CHECK A$ FOR TRAILING BLANKS                                       TRI00220
C                                                                        TRI00230
58    IM=)                                                               TRI00240
      DO 60 I=1,LA                                                       TRI00250
         INDEX=LA-I+1                                                    TRI00260
         IF(A$(INDEX).NE.BLNK) GOTO 65                                   TRI00270
         IM=IM+1                                                         TRI00280
60    CONTINUE                                                           TRI00290
65    IF(IM.EQ.0) GOTO 70                                                TRI00300
         IF(IPRT.GE.20) WRITE(6,207) IM                                  TRI00310
207      FORMAT(' FOUND',I3,' TRAILING BLANKS IN  STRING')               TRI00320
         IF(IM.NE.LA) GOTO 70                                            TRI00330
               LA=0                                                      TRI00340
               TRIM$=0                                                   TRI00350
               IF(IPRT.GE.20) WRITE(6,208)                               TRI00360
208            FORMAT(' FOUND STRING IS ALL BLANKS')                     TRI00370
               RETURN                                                    TRI00380
70       IEND=LA-IM                                                      TRI00390
C                                                                        TRI00400
C                                                                        TRI00410
C                                                                        TRI00420
C     CHECK A$ FOR LEADING BLANKS                                        TRI00430
C                                                                        TRI00440
C                                                                        TRI00450
      IM=0                                                               TRI00460
      DO 10 I=1,IEND                                                     TRI00470
         IF(A$(I).NE.BLNK) GOTO 15                                       TRI00480
```

```
          IM=IM+1                                                          TRI00490
10      CONTINUE                                                           TRI00500
15      IF(IM.EQ.0) GOTO 25                                                TRI00510
          IF(IPRT.GE.20) WRITE(6,211) IM                                   TRI00520
211       FORMAT(' FOUND',I3,' LEADING BLANKS IN STRING')                  TRI00530
25        IBEG=1+IM                                                        TRI00540
C                                                                          TRI00550
CC                                                                         TRI00560
CCC                                                                        TRI00570
C       DETERMINE LENGTH OF INPUT STRING                                   TRI00580
C                                                                          TRI00590
        LA=IEND-IBEG+1                                                     TRI00600
        IF(LA.LE.IDIM) GOTO 30                                             TRI00610
            LOSS=LA-IDIM                                                   TRI00620
            IF(IPRT.GE.10) WRITE(6,216) LOSS                               TRI00630
216         FORMAT(' STRING TOO LONG FOR MAX STRING LENGTH.  LOST',I3)     TRI00640
            LA=IDIM                                                        TRI00650
            IEND=IEND-LOSS                                                 TRI00660
C                                                                          TRI00670
CC                                                                         TRI00680
CCC                                                                        TRI00690
C       TRANSFER THE A$ CHARACTERS TO THE INPUT STRING.                    TRI00700
C                                                                          TRI00710
30      INDEX=1                                                            TRI00720
        DO 85 I=IBEG,IEND                                                  TRI00730
          A$(INDEX)=A$(I)                                                  TRI00740
          IF(IPRT.GE.30) WRITE(6,209) I,A$(I),INDEX,A$(INDEX)              TRI00750
209       FORMAT(' MOVE A$(',I3,')=',A1,'  IS NOW A$(',I3,')=',A1)         TRI00760
          INDEX=INDEX+1                                                    TRI00770
85      CONTINUE                                                           TRI00780
CC                                                                         TRI00790
CCC                                                                        TRI00800
C                                                                          TRI00810
C       CHECK FOR STRING ERROR  AND RETURN                                 TRI00820
C                                                                          TRI00830
        IF(IPRT.GE.10) WRITE(6,222)LA,(A$(I),I=1,LA)                       TRI00840
222     FORMAT(' TRIM$ ',I3,' AFTER :  ',11)A1)                            TRI00850
        IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                                TRI00860
C                                                                          TRI00870
CC                                                                         TRI00880
        TRIM$=LA                                                           TRI00890
        RETURN                                                             TRI00900
C                                                                          TRI00910
C       ERROR HANDLING SECTION FOLLOWS                                     TRI00920
C                                                                          TRI00930
6000    WRITE(6,6001) FUNC$                                                TRI00940
6001    FORMAT(' *** STRING LENGTH ERROR *** ',A4)                         TRI00950
        WRITE(6,6010) LA,LB,IDIM                                           TRI00960
```

```
 6010  FORMAT(' LA=',I10,'      LB=',I10,'      IDIM=',I10)                    TRI00970
       TRIM$=-1                                                               TRI00980
       RETURN                                                                 TRI00990
       END                                                                    TRI01000
```

```
      INTEGER FUNCTION XEQ$(A$,LA,M,M1)                                  XEQ00010
C*****************************************************************XEQ00020
C**                                                                 **XEQ00030
C**   STRING A$  HAS BEEN IDENTIFIED TO CONTAIN AN XEQ INSTRUCTION.  **XEQ00040
C**                                                                 **XEQ00050
C**                                                                 **XEQ00060
C**                                                                 **XEQ00070
C**   THE RETURN VALUE OF THE FUNCTION XEQ$ IS SET AS FOLLOWS:      **XEQ00080
C**        0  =  CONTINUE TO COMPILE                                **XEQ00090
C**       -1  =  AN ERROR IN COMPILING THE INSTRUCTION.             **XEQ00100
C**                                                                 **XEQ00110
C**                                                                 **XEQ00120
C*****************************************************************XEQ00130
      IMPLICIT INTEGER(A-Z)                                          XEQ00140
      COMMON/TEXT/IDIM,IPRT                                          XEQ00150
      COMMON/FLAGS/DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2  XEQ00160
      COMMON/CNTR/P1,P2,P3,P4,P5,P6,P7,P8,P9,S1,S2                   XEQ00170
      LOGICAL DONE,PDIGIT,PALPHA,DIGIT,ALPHA,INDIR,FLAG1,FLAG2       XEQ00180
      INTEGER*4 P1,P2,P3,P4,P5,P6,P7,P8,P9,S1,S2                     XEQ00190
      INTEGER*2 A$(IDIM)                                             XEQ00200
C     INTEGER*2 BLNK/' '/                                            XEQ00210
      INTEGER*2 QUOTE/'"'/                                           XEQ00220
      INTEGER*2 IND(3)/'I','N','D'/                                  XEQ00230
      INTEGER*2 LABEL(26)/'A','B','C','D','E','F','G','H','I','J',  XEQ00240
     2                    'T','Z','Y','X','L',' ',' ',' ',' ',' ',  XEQ00250
     3                    ' ',' ',' ',' ',' ',' ',' ',' '/          XEQ00260
      INTEGER*4 FUNC$/'XEQ'/                                         XEQ00270
      INTEGER*4 M(1)                                                 XEQ00280
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                   XEQ00290
200   FORMAT(' TRACE ',I3,' XEQ$    :  ',110A1)                      XEQ00300
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                            XEQ00310
C                                                                    XEQ00320
C                                                                    XEQ00330
C                                                                    XEQ00340
C     ESTABLISH DEFAULT PREFIX AND INSTRUCTION LENGTH VALUES         XEQ00350
C     (THESE ARE THE VALUES FOR 3 BYTE LOCAL NUMERIC XEQ  WITHOUT IND) XEQ00360
C                                                                    XEQ00370
         IBYTE=3                                                     XEQ00380
         PREFIX=224                                                  XEQ00390
C                                                                    XEQ00400
C                                                                    XEQ00410
C                                                                    XEQ00420
C     STRIP STRING OF "XEQ" CHARACTERS.                              XEQ00430
C                                                                    XEQ00440
         CALL LCUT$(A$,LA,3)                                         XEQ00450
         IF(TRIM$(A$,LA)) 6015,6015,10                               XEQ00460
C                                                                    XEQ00470
C                                                                    XEQ00480
```

```
C                                                                       XEQ00490
CCC     CHECK FOR ALPHANUMERIC VERSUS LOCAL LABELS                      XEQ00500
CCC                                                                     XEQ00510
10          IF(A$(1).EQ.QUOTE) GOTO 80                                  XEQ00520
CCC                                                                     XEQ00530
CCC                                                                     XEQ00540
CCC                                                                     XEQ00550
CCC     PROCESS LOCAL LABELS, FIRST CHECK FOR INDIRECT XEQ INSTR        XEQ00560
C                                                                       XEQ00570
            P6=POS$(A$,LA,IND,3,1)                                      XEQ00580
            IF(P6) 6015,20,16                                           XEQ00590
C                                                                       XEQ00600
CCC                                                                     XEQ00610
CCC                                                                     XEQ00620
CCC     PROCESS XEQ INDIRECT INSTRUCTION.                               XEQ00630
CCC                                                                     XEQ00640
16          P1=P6+3                                                     XEQ00650
            CALL LCUT$(A$,LA,P1)                                        XEQ00660
            IF(IPRT.GE.20)WRITE(6,235)                                  XEQ00670
235         FORMAT(' DETECTED INDIRECT  XEQ INSTRUCTION')               XEQ00680
            INDIR=.TRUE.                                                XEQ00690
            IBYTE=2                                                     XEQ00700
            PREFIX=174                                                  XEQ00710
C                                                                       XEQ00720
CCC                                                                     XEQ00730
CCC                                                                     XEQ00740
CCC     CHECK FOR NUMERIC OPERAND                                       XEQ00750
CCC                                                                     XEQ00760
20          IF(NUMC$(A$,LA,IANSW)) 6015,25,50                           XEQ00770
CCC                                                                     XEQ00780
CCC                                                                     XEQ00790
CCC                                                                     XEQ00800
CCC                                                                     XEQ00810
CCC                                                                     XEQ00820
CCC     OPERAND MUST BE REGISTER X,Y,Z,T CR L  OR A LOCAL ALPHA LABEL   XEQ00830
CCC                                                                     XEQ00840
25          DO 30 I=1,26                                                XEQ00850
                INDEX=I                                                 XEQ00860
                IF(A$(1).EQ.LABEL(I)) GOTO 35                           XEQ00870
30          CONTINUE                                                    XEQ00880
CCC                                                                     XEQ00890
C           WILL FALL THROUGH TO THIS CODE IF NO VALID LABEL FOUND      XEQ00900
            GOTO 6015                                                   XEQ00910
C                                                                       XEQ00920
CCC                                                                     XEQ00930
CCC                                                                     XEQ00940
CCC     HAVE FOUND A MATCH IN LOCAL LABEL TABLE, SET VALUE OF SECOND OPER-XEQ00950
C       AND.  THEN GOTO PROCESS A THREE BYTE INSTRUCTION.               XEQ00960
```

```
C                                                                       XEQ00970
35      INDEX=INDEX+101                                                 XEQ00980
        GOTO 75                                                         XEQ00990
C                                                                       XEQ01000
CCCCC                                                                   XEQ01010
CCCCC                                                                   XEQ01020
CCCCC                                                                   XEQ01030
CCCCC                                                                   XEQ01040
CCCCC   OPERAND  MUST BE A NUMERIC LOCAL LABEL                          XEQ01050
CCCCC                                                                   XEQ01060
50      IF(IVAL$(A$,LA,INDEX))6015,75,75                                XEQ01070
CCCCC                                                                   XEQ01080
CCCCC                                                                   XEQ01090
CCCCC                                                                   XEQ01100
CCCCC    PROCESS   THE GOTO   INSTRUCTION  (OPERAND>14)                 XEQ01110
C                                                                       XEQ01120
75      M(M1)=IBYTE                                                     XEQ01130
        IF(IPRT.GE.20)WRITE(6,210)M1,IBYTE                              XEQ01140
210     FORMAT('  XEQ$',I5,' LENGTH OF NEXT INSTR IS',I3)               XEQ01150
        M1=M1+1                                                         XEQ01160
C                                                                       XEQ01170
CCCCC                                                                   XEQ01180
CCCCC                                                                   XEQ01190
CCCCC   LOAD    THE     XEQ INSTR  PREFIX                               XEQ01200
C                                                                       XEQ01210
        M(M1)=PREFIX                                                    XEQ01220
        IF(IPRT.GE.10)WRITE(6,211)M1,M(M1)                              XEQ01230
211     FORMAT('  XEQ$',I5,' XEQ PREFIX     INSTR',T75,I3)            XEQ01240
        M1=M1+1                                                         XEQ01250
C                                                                       XEQ01260
CCCCC                                                                   XEQ01270
CCCCC                                                                   XEQ01280
CCCCC   LOAD THREE BYTE GOTO INSTR NULL INSTR (POSITION HOLDER FOR POINTERXEQ01290
C                                                                       XEQ01300
        IF(INDIR) GOTO 95                                               XEQ01310
        M(M1)=0                                                         XEQ01320
        IF(IPRT.GE.10)WRITE(6,221)M1,M(M1)                              XEQ01330
221     FORMAT('  XEQ$',I5,' NULL  FOR  XEQ INSTR',T75,I3)              XEQ01340
        M1=M1+1                                                         XEQ01350
C                                                                       XEQ01360
CCCCC                                                                   XEQ01370
CCCCC                                                                   XEQ01380
CCCCC   LOAD THE 2D OPERAND OF THE         XEQ INSTR                    XEQ01390
C                                                                       XEQ01400
95      IF(INDIR) INDEX=INDEX+128                                       XEQ01410
C       NOTE THAT FOR XEQ IND THE HIGH ORDER BIT IS SET                 XEQ01420
        M(M1)=INDEX                                                     XEQ01430
        IF(IPRT.GE.10)WRITE(6,212)M1,M(M1)                              XEQ01440
```

```
212       FORMAT('  XEQ$',I5,' XEQ 2D OPERAND     ',T75,I3)                    XEQ01450
          M1=M1+1                                                               XEQ01460
          XEQ$=0                                                                XEQ01470
          RETURN                                                                XEQ01480
C                                                                               XEQ01490
C                                                                               XEQ01500
C*****************************************************************************XEQ01510
C*****************************************************************************XEQ01520
C                                                                               XEQ01530
C                                                                               XEQ01540
C     PROCESS ALPHANUMERIC LABEL, FIRST LOOK FOR SECOND QUOTE                   XEQ01550
C                                                                               XEQ01560
80        K=0                                                                   XEQ01570
          P2=POS$(A$,LA,QUOTE,1,2)                                              XEQ01580
          IF(P2) 6015,120,85                                                    XEQ01590
C                                                                               XEQ01600
C                                                                               XEQ01610
C                                                                               XEQ01620
C     CHECK AFTER LAST QUOTE FOR BOGUS CHARACTERS                               XEQ01630
C                                                                               XEQ01640
85        LEFT=LA-P2                                                            XEQ01650
          IF(LEFT) 6015,100,6015                                                XEQ01660
C                                                                               XEQ01670
C                                                                               XEQ01680
C     DELETE THE ENDING QUOTE BY TRUNCATING THE STRING ONE CHAR                 XEQ01690
C                                                                               XEQ01700
100       LA=LA-1                                                               XEQ01710
C                                                                               XEQ01720
C                                                                               XEQ01730
C                                                                               XEQ01740
C     SET INSTRUCTION LENGTH FOR ALPHABETIC GLOBAL LABEL                        XEQ01750
C  (LINE 120 ACCOUNTS FOR BEGINNING QUOTE STILL ON STRING)                      XEQ01760
C                                                                               XEQ01770
120       LENGTH=LA-1                                                           XEQ01780
C         FOR GTO H=2      FOR LBL H=4          FOR XEQ H=2                   XEQ01790
          H=2                                                                   XEQ01800
          IBYTE=H+LENGTH                                                        XEQ01810
          M(M1)=IBYTE                                                           XEQ01820
          IF(IPRT.GE.20)WRITE(6,210)M1,IBYTE                                    XEQ01830
          M1=M1+1                                                               XEQ01840
C                                                                               XEQ01850
C                                                                               XEQ01860
C                                                                               XEQ01870
C     HAVE FOUND VALID ALPHANUMERIC  LABEL,     LOAD "XEQ" INSTRUCTION        XEQ01880
C                                                                               XEQ01890
          PREFIX=30                                                             XEQ01900
C         FOR GTO PREFIX=29    FOR LBL PREFIX=192    FOR XEQ PREFIX=30        XEQ01910
          M(M1)=PREFIX                                                          XEQ01920
```

```
      IF(IPRT.GE.10)WRITE(6,214)M1,M(M1)                                XEQ01930
214   FORMAT('  XEQ$',I5,' ALPHA     XEQ INSTR',T75,I3)                 XEQ01940
      M1=M1+1                                                           XEQ01950
C                                                                       XEQ01960
CC                                                                      XEQ01970
CCC                                                                     XEQ01980
CCCC                                                                    XEQ01990
CCCCC                                                                   XEQ02000
CC    SET INDICATOR FOR NUMBER OF ALPHA CHARS IN LABEL                  XEQ02010
C                                                                       XEQ02020
      U=240                                                             XEQ02030
C     FOR GTO U=240     FOR LBL   U=241       FOR XEQ U=240           XEQ02040
      M(M1)=U+LENGTH                                                    XEQ02050
      IF(IPRT.GE.10)WRITE(6,216)M1,M(M1)                                XEQ02060
216   FORMAT('  XEQ$',I5,' LENGTH CODE ALPH XEQ',T75,I3)                XEQ02070
      M1=M1+1                                                           XEQ02080
C                                                                       XEQ02090
CC                                                                      XEQ02100
CCC                                                                     XEQ02110
CCCC                                                                    XEQ02120
CCCCC                                                                   XEQ02130
CC    ADD ALPHABETIC CHARACTERS AND RETURN                              XEQ02140
C                                                                       XEQ02150
140   LA=LENGTH+1                                                       XEQ02160
      XEQ$=ALPH$(A$,LA,M,M1)                                            XEQ02170
      RETURN                                                            XEQ02180
C                                                                       XEQ02190
CC                                                                      XEQ02200
CC    ERROR HANDLING SECTION FOLLOWS                                    XEQ02210
C                                                                       XEQ02220
6000  WRITE(6,6001) FUNC$                                               XEQ02230
6001  FORMAT(' *** STRING LENGTH ERROR *** ',A4)                        XEQ02240
      WRITE(6,6010) LA,LB,IDIM                                          XEQ02250
6010  FORMAT(' LA=',I10,'     LB=',I10,'     IDIM=',I10)                XEQ02260
      XEQ$=-1                                                           XEQ02270
      RETURN                                                            XEQ02280
6015  WRITE(6,6016)                                                     XEQ02290
6016  FORMAT(' ***** INVALID SECOND OPERAND IN XEQ INSTR ****')         XEQ02300
      XEQ$=-1                                                           XEQ02310
      RETURN                                                            XEQ02320
6020  WRITE(6,6021)                                                     XEQ02330
6021  FORMAT(' ***** FOUND THREE OPERANDS, EXPECTING IND *****')        XEQ02340
      XEQ$=-1                                                           XEQ02350
      RETURN                                                            XEQ02360
      END                                                               XEQ02370
```

```
      INTEGER FUNCTION XRO$(A$,LA,M,M1)                                  XR000010
C*****************************************************************     *XR000020
C**                                                                     **XR000030
C**    STRING A$ HAS BEEN IDENTIFIED TO CONTAIN AN XROM INSTRUCTION.    **XR000040
C**                                                                     **XR000050
C**    THE XROM INSTRUCTIONS ARE SUBROUTINE CALLS TO HP SUPPLIED        **XR000060
C**    ROM ENCODED SUBROUTINES.  THE SECOND AND THIRD OPERANDS MUST     **XR000070
C**    BE NUMERIC.                                                      **XR000080
C**                                                                     **XR000090
C**                                                                     **XR000100
C**                                                                     **XR000110
C**                                                                     **XR000120
C**    THE RETURN VALUE OF THE FUNCTION XRO$ IS SET AS FOLLOWS:         ** XR000130
C**         0  =  CONTINUE TO COMPILE                                   **XR000140
C**        -1  =  AN ERROR IN COMPILING THE INSTRUCTION.                **XR000150
C**                                                                     **XR000160
C**                                                                     **XR000170
C*****************************************************************     *XR000180
      IMPLICIT INTEGER(A-Z)                                              XR000190
      COMMON/TEXT/IDIM,IPRT                                              XR000200
      INTEGER*2 A$(IDIM)                                                 XR000210
      INTEGER*2 COMMA/','/,SS1$(40)                                      XR000220
      INTEGER*4 FUNC$/'XRO'/                                             XR000230
      INTEGER*4 M(1)                                                     XR000240
      REAL*4 RFRAC,RDIF                                                  XR000250
      IF(IPRT.GE.10) WRITE(6,200)LA,(A$(I),I=1,LA)                       XR000260
200   FORMAT(' TRACE ',I3,' XRO$    :  ',110A1)                          XR000270
      IF(LA.GT.IDIM.OR.LA.LT.0) GOTO 6000                                XR000280
C                                                                        XR000290
C                                                                        XR000300
C                                                                        XR000310
      IF(LCUT$(A$,LA,4)) 6015,6020,7                                     XR000320
7     IF(TRIM$(A$,LA))   6015,6020,10                                    XR000330
10    P1=POS$(A$,LA,COMMA,1,1)                                           XR000340
      P2=P1-1                                                            XR000350
      IF(SEG$(A$,LA,SS1$,LSS1,1,P2))6015,6020,12                         XR000360
12    IF(LCUT$(A$,LA,P1)) 6015,6020,15                                   XR000370
15    IF(IVAL$(SS1$,LSS1,ROM)) 6030,20,20                                XR000380
20    IF(IVAL$(A$,LA,PGM)) 6030,25,25                                    XR000390
25    IFRAC=ROM/4                                                        XR000400
      IFIRST=160+IFRAC                                                   XR000410
      RFRAC=FLOAT(ROM)/4.0                                               XR000420
      RDIF=RFRAC-FLOAT(IFRAC)                                            XR000430
      RDIF=256.0*RDIF                                                    XR000440
      IDIF=INT(RDIF)                                                     XR000450
      ISECND=PGM+IDIF                                                    XR000460
C                                                                        XR000470
C                                                                        XR000480
```

```
C       SET THE LENGTH OF THE INSTRUCTION                                XR000490
C                                                                        XR000500
100        IBYTE=2                                                       XR000510
           M(M1)=IBYTE                                                   XR000520
           IF(IPRT.GE.20)WRITE(6,215)M1,IBYTE                            XR000530
215        FORMAT('  XRO$',I5,' LENGTH OF THIS INSTR IS',I3)             XR000540
           M1=M1+1                                                       XR000550
C                                                                        XR000560
CCC                                                                      XR000570
CCC                                                                      XR000580
CCC     ENCODE THE PREFIX OF THIS INSTRUCTION                            XR000590
C                                                                        XR000600
           M(M1)=IFIRST                                                  XR000610
           IF(IPRT.GE.10)WRITE(6,211)M1,IFIRST,ROM,M(M1)                 XR000620
211        FORMAT('  XRO$',I5,' PREFIX= ',I3,' ROM= ',I3,T75,I3)        XR000630
           M1=M1+1                                                       XR000640
C                                                                        XR000650
CCC                                                                      XR000660
CCC                                                                      XR000670
CCC     ENCODE THE POSTFIX OF THIS INSTRUCTION                           XR000680
C                                                                        XR000690
           M(M1)=ISECND                                                  XR000700
           IF(IPRT.GE.10)WRITE(6,221)M1,ISECND,PGM,M(M1)                 XR000710
221        FORMAT('  XRO$',I5,' POSTFIX=',I3,' PGM= ',I3,T75,I3)        XR000720
           M1=M1+1                                                       XR000730
C                                                                        XR000740
CCC                                                                      XR000750
CCC                                                                      XR000760
                                                                         XR000770
C                                                                        XR000780
CCC                                                                      XR000790
CCC                                                                      XR000800
125     XRO$=0                                                           XR000810
        RETURN                                                           XR000820
C                                                                        XR000830
CCC     ERROR HANDLING SECTION FOLLOWS                                   XR000840
C                                                                        XR000850
6000    WRITE(6,6001) FUNC$                                              XR000860
6001    FORMAT(' *** STRING LENGTH ERROR *** ',A4)                       XR000870
        WRITE(6,6010) LA,IDIM                                            XR000880
6010    FORMAT(' LA=',I10,'                    IDIM=',I10)               XR000890
        XRO$=-1                                                          XR000900
        RETURN                                                           XR000910
6015    WRITE(6,6016)                                                    XR000920
6016    FORMAT(' ***** INVALID ROM NUMBER IN XRO INSTR ****')            XR000930
        XRO$=-1                                                          XR000940
        RETURN                                                           XR000950
6020    WRITE(6,6021)                                                    XR000960
```

```
6021  FORMAT(' ***** INVALID PROGRAM NUMBER IN XRC INSTR *****')          XR000970
      XRO$=-1                                                             XR000980
      RETURN                                                              XR000990
6030  WRITE(6,6031)                                                       XR001000
6031  FORMAT(' ****** NUMERIC CONVERSION ERROR IN XRO INSTR ****')        XR001010
      XRO$=-1                                                             XR001020
      RETURN                                                              XR001030
      END                                                                 XR001040
```

```
C**********************************************************************VER00010
C**                                                                    **VER00020
C**     THIS IS THE PROGRAM WHICH INTERFACES THE HP41CV CROSS COMPILER **VER00030
C**     TO THE VERSATEC HIGH RESOLUTION PLOTTER.  IF THE CROSS         **VER00040
C**     COMPILER IS USED ON A DIFFERENT PLOTTER, ONLY THIS ROUTINE     **VER00050
C**     NEEDS TO BE CHANGED.                                           **VER00060
C**                                                                    **VER00070
C**********************************************************************VER00080
      REAL*4  HEIGHT,UNIT,DOUBLE,CSIZE,CSPACE,TSIZE,TSPACE             VER00090
      REAL*4  PLONG,PWIDE,HFACTR,ZERO,TMAR,SMAR                        VER00100
      INTEGER*2 IN(133),BLNK/' '/,ZER/'0'/,ONE/'1'/,TITLE(80)          VER00110
      INTEGER*4 PERPGE,IROW                                            VER00120
C                                                                      VER00130
C                                                                      VER00140
C                                                                      VER00150
C     INITIALIZE VARIABLES AND POSITION PEN AT ORIGIN                  VER00160
C                                                                      VER00170
C     ONLY TWO VARIABLES (NIBS AND HEIGHT) SHOULD BE CHANGED BY        VER00180
C     THE USER.  OTHER VARIABLES ARE COMPUTED BASED ON THESE           VER00190
C     VARIABLES.                                                       VER00200
C                                                                      VER00210
C     NIBS IS THE WIDTH OF THE PLOTTER LINE  (INTEGER 1 TO 4)          VER00220
C     SETTING NIBS AFFECTS THE WIDTH OF THE BAR CODE ROW.  A           VER00230
C     SETTING OF 4 WILL GIVE BARS OF 5 TO 6.5 INCHES IN WIDTH.         VER00240
C                                                                      VER00250
      NIBS=4                                                           VER00260
C                                                                      VER00270
C                                                                      VER00280
C                                                                      VER00290
C     HEIGHT IS THE BASIC HEIGHT OF THE BAR CODE ROW.  BARS MAY BE     VER00300
C     MADE IN ALMOST ANY HEIGHT FROM 0.2 TO 0.5 INCHES.  RECOMMEND     VER00310
C     A HEIGHT OF 0.40 INCHES, WHICH WILL GIVE 12 BARS PER PAGE.       VER00320
C                                                                      VER00330
C     HEWLETT-PACKARDS BARS ARE .33 INCHES HIGH                        VER00340
C                                                                      VER00350
      HEIGHT=0.40                                                      VER00360
C                                                                      VER00370
C                                                                      VER00380
C     UNIT IS THE BASIC UNIT WIDTH -- IT IS THE WIDTH OF THE           VER00390
C          SPACE BETWEEN BARS AND THE WIDTH OF A ZERO BAR.             VER00400
      UNIT=0.005*FLOAT(NIBS)                                           VER00410
C     DOUBLE IS TWICE THE WIDTH OF A UNIT BAR -- --IT IS THE WIDTH     VER00420
C          OF A ONE BAR.                                               VER00430
      DOUBLE=0.010*FLOAT(NIBS)                                         VER00440
C     CSIZE IS THE HEIGHT OF THE BAR CODE ROW NUMBER                   VER00450
      CSIZE=0.15*HEIGHT                                                VER00460
C     CSPACE IS THE HEIGHT OF THE SPACE BETWEEN THE BAR CODE ROW       VER00470
C          NUMBER AND THE ACTUAL BAR CODE ROW ITSELF.                  VER00480
```

```
            CSPACE=0.08*HEIGHT                                              VER00490
C       TSIZE IS THE HEIGHT OF THE TITLE CHARACTERS.                        VER00500
            TSIZE=0.22*HEIGHT                                               VER00510
C       TSPACE IS THE HEIGHT OF THE SPACE BETWEEN THE TITLE AND THE         VER00520
C           FIRST BARCODE ROW NUMBER.                                       VER00530
            TSPACE=CSIZE+(1.5*CSPACE)                                       VER00540
C       HFACTR IS THE RELATIVE HEIGHT OF THE SUM OF THE BAR HEIGHT          VER00550
C           PLUS THE SPACE BETWEEN THE BARS, INCLUDING LABELS               VER00560
            HFACTR=1.7*HEIGHT                                               VER00570
C       PLONG IS THE HEIGHT OF EACH PAGE OF BARCODE                         VER00580
            PLONG=11.0                                                      VER00590
C       PWIDE IS THE WIDTH OF EACH PAGE CF BARCODE                          VER00600
            PWIDE=8.5                                                       VER00610
C       TMAR IS THE HEIGHT OF THE TOP MARGIN OF THE PAGE                    VER00620
            TMAR=1.0                                                        VER00630
C       ESPACE IS THE HEIGHT OF THE MARGINS REPRESENTS HOW                  VER00640
C           FAR THE PAPER IS ADVANCED BETWEEN PAGES                         VER00650
            ESPACE=TMAR+1.5                                                 VER00660
C       SMAR IS THE HEIGHT OF THE LEFT SIDE MARGIN ON THE PAGE              VER00670
            SMAR=1.5                                                        VER00680
C       ZERO IS A LEFT MARGIN OFFSET USED TO MOVE THE PHYSICAL              VER00690
C           PLOT AWAY FROM THE LEFT MARGIN OF THE PLOTTER                   VER00700
            ZERO=3.0                                                        VER00710
C       PERPGE IS THE NUMBER OF BARCODE ROWS THAT WILL BE DRAWN PER PAGE    VER00720
             PERPGE=IFIX((PLONG-ESPACE)/HFACTR)                             VER00730
            CALL PLOTS(),0,0)                                               VER00740
            CALL PLOT(0.0,0.0,3)                                            VER00750
            IROW=0                                                          VER00760
            IPRT=0                                                          VER00770
            X=TMAR                                                          VER00780
            Y=ZERO                                                          VER00790
C                                                                           VER00800
C                                                                           VER00810
C                                                                           VER00820
C     READ THE TITLE OF THE BARCODE PROGRAM FROM THE INPUT FILE             VER00830
C                                                                           VER00840
      READ(5,103)(TITLE(I),I=1,80)                                          VER00850
103   FORMAT(80A1)                                                          VER00860
C                                                                           VER00870
C                                                                           VER00880
C                                                                           VER00890
C     READ THE ROW OF ZERO'S AND ONE'S FROM THE INPUT FILE                  VER00900
C                                                                           VER00910
10    READ(5,101,END=3000)(IN(I),I=1,132)                                   VER00920
101   FORMAT(66A1,/,5X,66A1)                                                VER00930
      IF(IPRT.GE.20) WRITE(6,201) (IN(I),I=1,132)                           VER00940
201   FORMAT(' ',132A1)                                                     VER00950
C                                                                           VER00960
```

```
C
CCC     WRITE THE TITLE ON THE PLOT
CCC
20          IF(MOD(IROW,PERPGE).NE.0)GOTO 30
            X=X+ESPACE
            CALL NEWPEN(2)
            XM1=X-TMAR
            XM2=X+PLONG-TMAR
            YM1=Y-SMAR
            YM2=Y+PWIDE-SMAR
            CALL PLOT(XM1,YM1,3)
            CALL PLOT(XM2,YM1,2)
            CALL PLOT(XM2,YM2,2)
            CALL PLOT(XM1,YM2,2)
            CALL PLOT(XM1,YM1,2)
            CALL PLOT(X,Y,3)
            CALL SYMBOL(X,Y,TSIZE,TITLE,90.0,72)
            CALL NEWPEN(NIBS)
            X=X+TSPACE
            Y=ZERO
            CALL PLOT(X,Y,3)
C
CCCCC
CCCCC   LABEL THE BAR CODE ROW
CCCCC
30          ROWNUM=ROWNUM+1.0
            IROW=IROW+1
            CALL NEWPEN(2)
            CALL NUMBER(X,Y,CSIZE,ROWNUM,90.0,-1)
            CALL NEWPEN(NIBS)
            X=X+CSPACE
            CALL PLOT(X,Y,3)
C
CCCC    CONVERT THE ZERO'S AND ONE'S INTO BARS OF CORRECT WIDTH
C       DO 1000  I=1,132
CCCCC
CCCCC
CCCC    CHECK FOR ZERO OR ONE BIT
50          IF(IN(I).EQ.ZER) GOTO 100
            IF(IN(I).EQ.ONE) GOTO 200
            IF(IN(I).EQ.BLNK) GOTO 2000
C
CCC
C
```

```
VER00970
VER00980
VER00990
VER01000
VER01010
VER01020
VER01030
VER01040
VER01050
VER01060
VER01070
VER01080
VER01090
VER01100
VER01110
VER01120
VER01130
VER01140
VER01150
VER01160
VER01170
VER01180
VER01190
VER01200
VER01210
VER01220
VER01230
VER01240
VER01250
VER01260
VER01270
VER01280
VER01290
VER01300
VER01310
VER01320
VER01330
VER01340
VER01350
VER01360
VER01370
VER01380
VER01390
VER01400
VER01410
VER01420
VER01430
VER01440
```

```
C      DRAW A ZERO BAR OF UNIT WIDTH                                    VER01450
C                                                                       VER01460
100             X=X+HEIGHT                                              VER01470
                CALL PLOT(X,Y,2)                                        VER01480
                Y=Y+DOUBLE                                              VER01490
                X=X-HEIGHT                                              VER01500
                CALL PLOT(X,Y,3)                                        VER01510
                GOTO 1000                                               VER01520
C                                                                       VER01530
CCC                                                                     VER01540
CCCCC                                                                   VER01550
                                                                        VER01560
CCCCC                                                                   VER01570
                                                                        VER01580
C      DRAW A ONE BAR OF DOUBLE UNIT WIDTH                              VER01590
C                                                                       VER01600
200             X=X+HEIGHT                                              VER01610
                CALL PLOT(X,Y,2)                                        VER01620
                Y=Y+UNIT                                                VER01630
                X=X-HEIGHT                                              VER01640
                CALL PLOT(X,Y,3)                                        VER01650
                X=X+HEIGHT                                              VER01660
                CALL PLOT(X,Y,2)                                        VER01670
                Y=Y+DOUBLE                                              VER01680
                X=X-HEIGHT                                              VER01690
                CALL PLOT(X,Y,3)                                        VER01700
                GOTO 1000                                               VER01710
C                                                                       VER01720
CCC                                                                     VER01730
                                                                        VER01740
1000        CONTINUE                                                    VER01750
CCC                                                                     VER01760
                                                                        VER01770
CCCCC                                                                   VER01780
C      GOTO NEXT ROW                                                    VER01790
C                                                                       VER01800
2000        X=X+HFACTR                                                  VER01810
            Y=ZERO                                                      VER01820
            CALL PLOT(X,Y,3)                                            VER01830
            GOTO 10                                                     VER01840
C                                                                       VER01850
CCC                                                                     VER01860
                                                                        VER01870
C      FINISH UP THE PLOT:  PROGRAM IS COMPLETE                         VER01880
C                                                                       VER01890
3000        CALL PLOT(0.,0.,+999)                                       VER01900
            STOP                                                        VER01910
            END                                                         VER01920
```

THE FOLLOWING IS THE DATA SET READ BY THE CROSS COMPILER.

```
0   62
HP41C SOURCE CODE:
+                64     7     1     1     1
-                65     8     6     1     1
*                66     6     5     1     1
/                67     9     7     1     1
X<Y?             68    97    92     4     1
X>Y?             69   101    95     4     1
X<=Y?            70    94    90     5     1
&+               71     3     2     2     1
&-               72     4     3     2     1
HMS+             73    50    48     4     1
HMS-             74    51    49     4     1
MOD              75    60    58     3     1
&                76     1     8     1     1
&CH              77     2     9     3     1
P-R              78    63    61     3     1
R-P              79    68    67     3     1
LN               80    56    54     2     1
X|2              81   102    94     3     1
SQRT             82    80    78     4     1
Y|X              83   103   101     3     1
CHS              84    25    23     3     1
E|X              85    39    35     3     1
LOG              86    58    56     3     1
10|X             87    11   103     4     1
E|X-1            88    40    38     5     1
SIN              89    79    77     3     1
COS              90    32    30     3     1
TAN              91    87    85     3     1
ASIN             92    19    17     4     1
ACOS             93    13    11     4     1
ATAN             94    21    19     4     1
DEC              95    34    32     3     1
1/X              96    10   102     3     1
ABS              97    12    10     3     1
FACT             98    41    39     4     1
X#0?             99    90    98     4     1
X>0?            100   100    96     4     1
LN1+X           101    57    55     5     1
X<0?            102    92    93     4     1
X=0?            103    98   100     4     1
INT             104    53    51     3     1
FRC             105    45    43     3     1
D-R             106    33    31     3     1
R-D             107    67    66     3     1
HMS             108    49    47     3     1
HR              109    52    50     2     1
RND             110    72    71     3     1
OCT             111    61    59     3     1
CLΣ             112    26    24     3     1
X<>Y            113    96    89     4     1
PI              114    64    62     2     1
CLST            115    30    28     4     1
RT              116    74    65     2     1
RDN             117    71    70     3     1
LASTX           118    55    53     5     1
```

CLX	119	31	29	3	1
X=Y?	120	99	99	4	1
X#Y?	121	91	97	4	1
SIGN	122	78	75	4	1
X<=0?	123	93	91	5	1
MEAN	124	55	57	4	1
SDEV	125	76	74	4	1
AVIEW	126	22	20	5	1
CLD	127	28	26	3	1
DEG	128	35	33	3	1
RAD	129	69	68	3	1
GRAD	130	48	46	4	1
ENTER↑	131	38	37	6	1
STOP	132	86	84	4	1
RTN	133	73	72	3	1
BEEP	134	23	21	4	1
CLA	135	27	25	3	1
ASTF	136	18	16	4	1
PSE	137	66	64	3	1
CLRG	138	29	27	4	1
AOFF	139	15	13	4	1
AON	140	16	14	3	1
OFF	141	62	60	3	1
PROMPT	142	65	63	6	1
ADV	143	14	12	3	1
RCL	144	70	69	3	2
STO	145	85	83	3	2
ST+	146	82	79	3	2
ST-	147	83	81	3	2
ST*	148	81	80	3	2
ST/	149	84	82	3	2
ISG	150	54	52	3	2
DSE	151	36	34	3	2
VIEW	152	89	87	4	2
&REG	153	5	4	4	2
ASTO	154	20	18	4	2
ARCL	155	17	15	4	2
FIX	156	44	42	3	2
SCI	157	75	73	3	2
ENG	158	37	36	3	2
TONE	159	38	86	4	2
XRCM	160			4	2
XRCM	161			4	2
XRCM	162			4	2
XRCM	163			4	2
XRCM	164			4	2
XRCM	165			4	2
XRCM	166			4	2
XRCM	167			4	2
SF	168	77	75	2	2
CF	169	24	22	2	2
FS?C	170	47	45	4	2
FC?C	171	43	41	4	2
FS?	172	46	44	3	2
FC?	173	42	40	3	2
X<>	206	95	88	3	2

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